ANNUAL REPORT 1959

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Fort Collins, Colorado   Raymond Price, Director

Forest Service - U.S. Department of Agriculture

LOCATION OF FIELD UNITS

RESEARCH CENTERS

Albuquerque, New Mexico
Marron Hall
University of New Mexico

Flagstaff, Arizona
Arizona State College

Fort Collins, Colorado
Braiden Hall
Colorado State University

Grand Junction, Colorado
Post Office Building

Laramie, Wyoming
Agriculture Building
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
South Dakota School of Mines and Technology

Tempe, Arizona
Agriculture Building
Arizona State College

Tucson, Arizona
University of Arizona

RESEARCH LABORATORIES

Forest Diseases:

Albuquerque, New Mexico
New Federal Building

Fort Collins, Colorado
South Hall
Colorado State University

Forest Insects:

Albuquerque, New Mexico
New Federal Building

Fort Collins, Colorado
South Hall
Colorado State University

ANNUAL REPORT

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

CALENDAR YEAR 1959

The Station maintains central headquarters at Fort Collins, Colorado, in cooperation with Colorado State University

(Not for publication)

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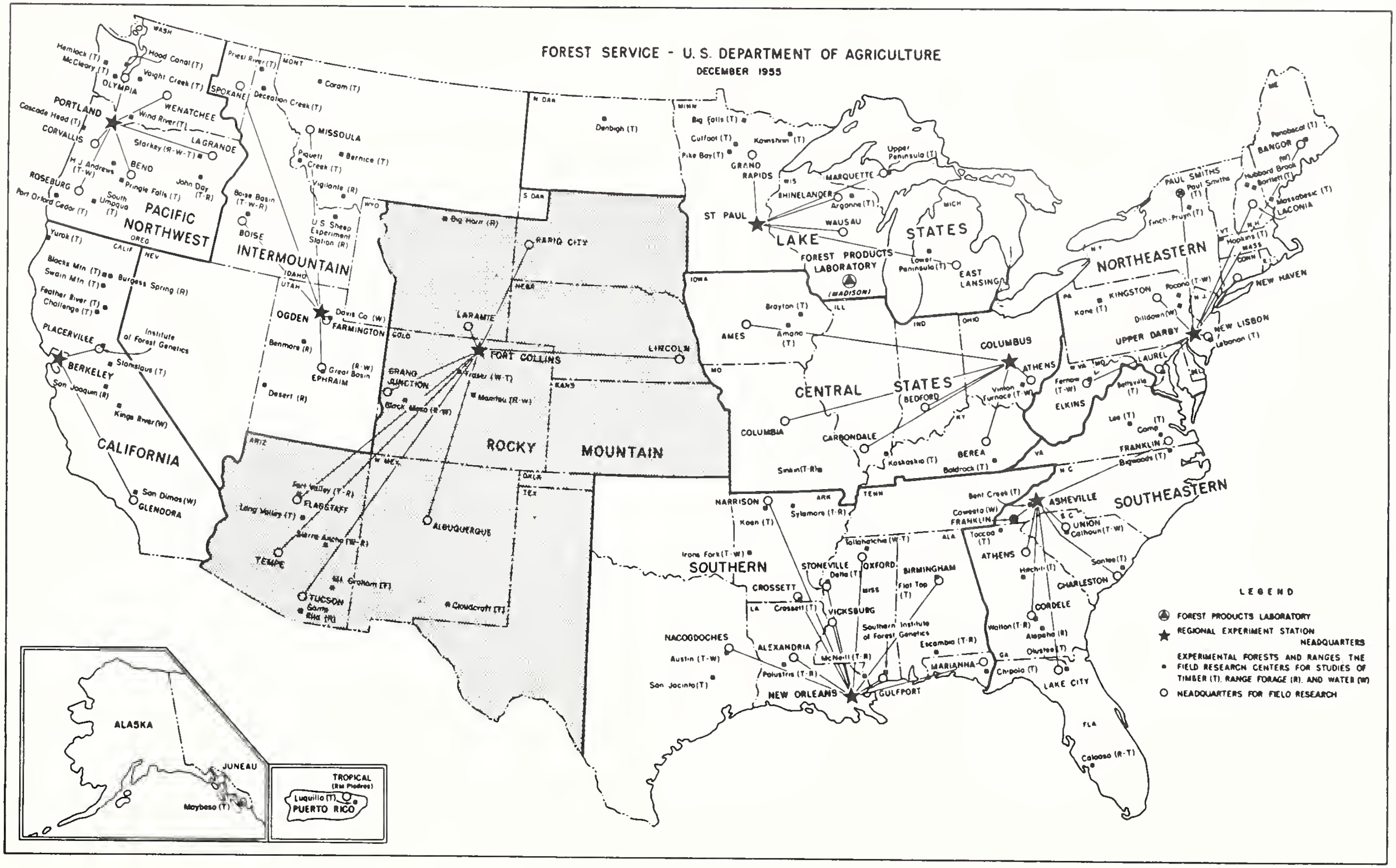


Location of the forest and range experiment stations and the Forest Products Laboratory

INTRODUCTION

The forest research program at the Rocky Mountain Station in 1959 was reappraised in the light of several new studies begun in 1958 and in relation to other studies well underway.

The emphasis this year was aimed at consolidating the small program gains of 1958 to achieve greater coordination with established going programs. Also, more attention was given to the publication and the application of research results. Publication output has doubled during the year.

Reappraisal of our program emphasized the need to increase our efforts in basic research and in the improvement of our physical facilities for such research. It has also pointed to the need for attaining greater depth in our research attack on certain resource and land-management problems. Progress has been made along these lines in the past year. Reorientation of research at the field units to place greater emphasis on the primary problems has been launched and is well underway.

Some small progress has been made in improving our physical facilities for basic research. A combined office and laboratory is nearing completion at Rapid City, South Dakota, which will greatly facilitate our forest management and utilization research. Similarly, modern greenhouses have been constructed at Fort Collins, Colorado, and at Tempe, Arizona, which will permit strengthening research in several fields, particularly forest diseases, forest insects, and use of chemicals in plant control in watershed-manipulation studies.

An equally important facet is the training of our research staff. Each year an increasing number of our scientists are seeking advanced training in various specialized fields to prepare themselves for the complexities of their research problems. About 70 percent of our technical staff have obtained advanced degrees, one-fourth of whom have their doctorates. This past year 17 of our scientists undertook advanced training at their own expense. These are all steps essential in getting our organization, our people, and our facilities geared to the solution of the many growing forest research problems.

Highlights of research findings on going projects during the past year are presented in the following pages. A more detailed account of research results is released through various publications. An annotated list of publications issued in 1959 is included in the bibliography at the end of this report.

RANGE MANAGEMENT

AND WILDLIFE HABITAT RESEARCH

PONDEROSA PINE RANGES

Shade-grown plants high in crude fiber and low in nitrogen-free extract

Crude fiber and nitrogen-free extract content of grasses and sedges grown in the open differed from that of plants grown under a ponderosa pine overstory in the Black Hills of South Dakota. Average content of the plants from grassland openings and nearby forests were:

	Open grown	Shade grown
	- (Percent) -	
Crude fiber	27	30
Nitrogen-free extract	50	44

These differences may be one reason why livestock prefer open-grown plants. Utilization by cattle of grasses and sedges in areas where the plants were collected averaged between 45 and 50 percent on the grassland but less than 5 percent on adjacent timbered ranges.

No differences were found between open- and shade-grown grasses and sedges in the amount of protein, calcium, phosphorus, ash, or ether extract.

Protein levels of Kentucky bluegrass (*Poa pratensis*) were lower on all collection areas in 1958 than in 1957 (fig. R-1). This may have been related to lower precipitation and moisture content of the plants that reduced growth in 1958. Precipitation from May to October 15 at the collection sites was 5.1 inches lower in 1958 than it had been in 1957. Moisture content of the plants averaged 53.9 percent from June 4 to October 15 in 1958, 7.4 percent less than the average during the same period in 1957. Chemical analyses were made in cooperation with the South Dakota Agricultural Experiment Station.

Planted browse species show good growth

Antelope bitterbrush (*Purshia tridentata*), not native to the Black Hills, shows considerable promise as a shrub for planting depleted deer range. In 1959, 2 years after planting on an old burn, bitterbrush leaders averaged 7 inches in length and some exceeded 13 inches. Maximum leader growth in 1958 (1 year after planting) was 6.5 inches and averaged 3.0 inches.

Chokecherry (*Prunus virginiana*) and mountainmahogany (*Cercocarpus montanus*), both native species, planted on the same site, made less growth than bitterbrush. Growth of all species was poorer on a planting site under a ponderosa pine stand.

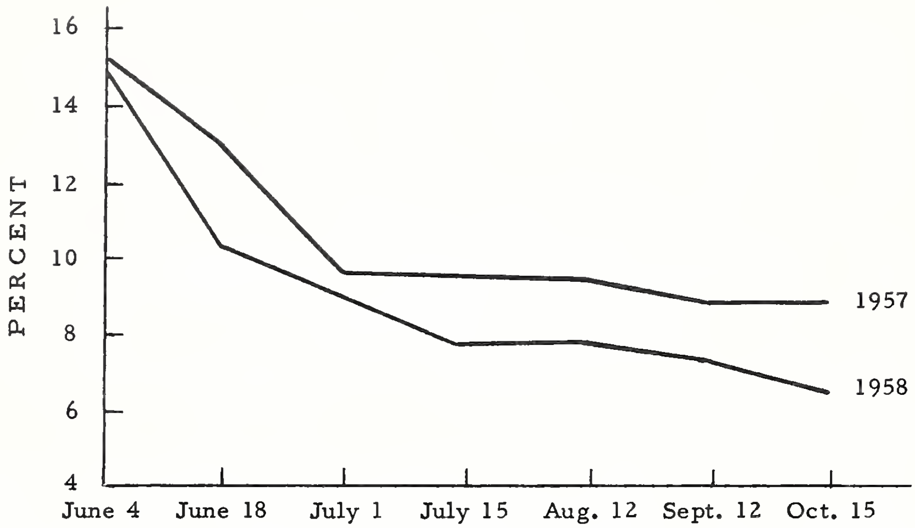


Figure R-1. --Average protein content of Kentucky bluegrass collected in the Black Hills in 1957 and 1958.

Silverberry (Elaeagnus argentea) planted as nursery stock grew well, but chokecherry and serviceberry (Amelanchier alnifolia) nursery stock put on little or no growth at the 2 planting sites in 1959. All grew better on the burn than under the pine stand. Average growth of seedlings and nursery stock at both planting sites is shown in figure R-2.

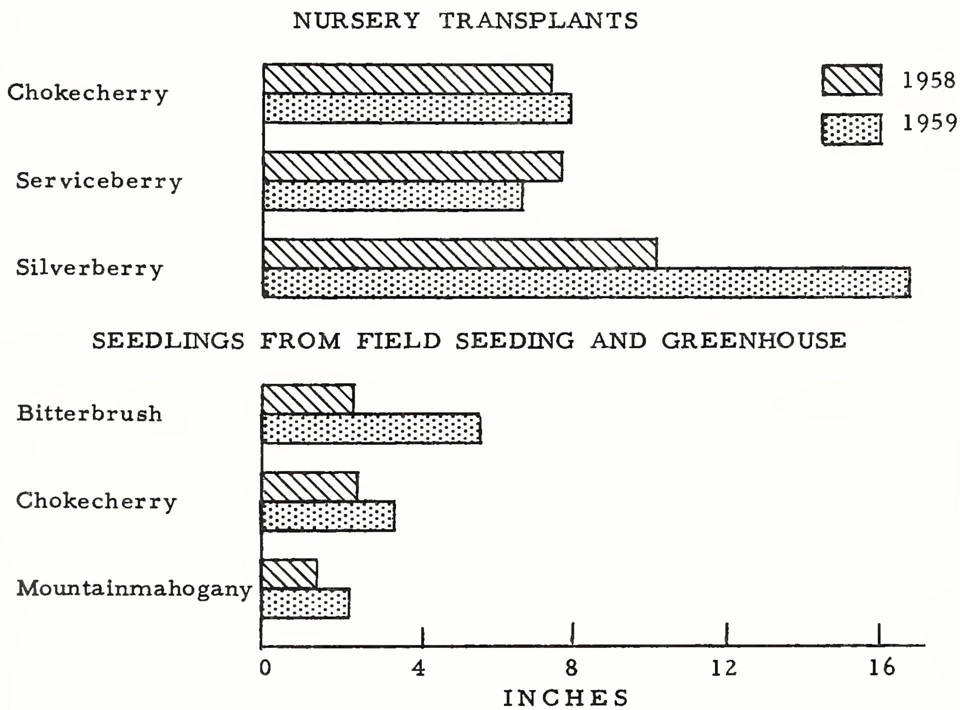


Figure R-2. --Average heights, after 1 growing season (1958) and 2 growing seasons (1959), of browse species seeded and transplanted at 2 sites in the Black Hills.

The small browse plants died from many causes. Newly emerged seedlings succumbed to freezing, frost-heaving, damping off, and insects. Some were covered by litter or washed away by storm runoff. In summer, drought and insect defoliators took their toll. In fall and winter, prolonged cold, dry weather, and browsing by deer, rabbits, and small rodents killed some young seedlings.

Weight gains per heifer decrease as grazing intensity increases and season progresses

Weight gains on yearling heifers were inversely related to intensity of grazing on pine-bunchgrass ranges at Manitou Experimental Forest, Colorado (fig. R-3).

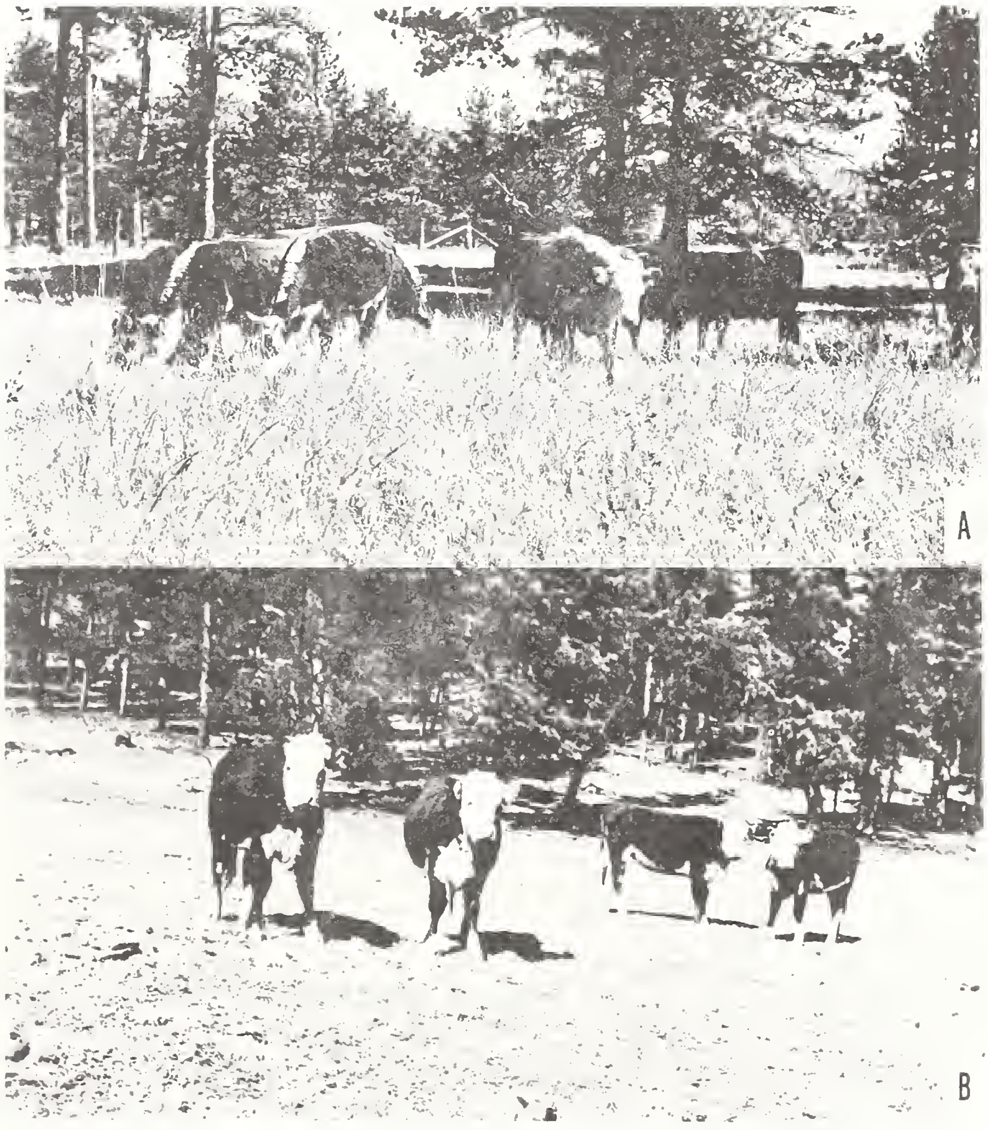


Figure R-3. --Heifers on grazing experiment, Manitou Experimental Forest, Colorado, A, on lightly grazed ranges and B, on heavily grazed ranges.

Over an 18-year period average gains from June 1 to October 31 for heifers on ranges grazed lightly (removal of 10 to 20 percent of the grass and sedge herbage) was 210 pounds. Heifers grazing at a level that removed 30 to 40 percent of the herbage gained 201 pounds, while those that utilized more than 50 percent put on only 151 pounds. The greatest gains, regardless of grazing intensity, were made in June, and the rate of gain decreased progressively as the season advanced (fig. R-4). On heavily grazed ranges, more than 90 percent of the weight increases were made in June, July, and August. During these same 3 months 84 and 80 percent of the total weight gains were obtained on ranges grazed at the moderate and light intensities, respectively. September gains dropped sharply on heavy-use ranges, while October grazing produced negligible, if any, gains under all grazing intensities.

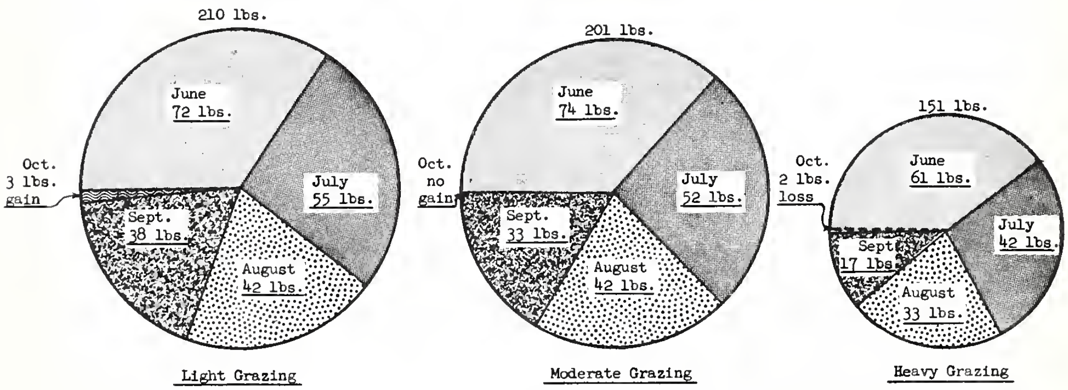


Figure R-4. --Heifer weight gains decrease as grazing intensity increases and season progresses. Manitou Experimental Forest, Colorado.

Cattle graze more plants, but to the same degree, with heavier use

On ponderosa pine-bunchgrass ranges at Manitou Experimental Forest, a study in 1957 showed that cattle removed about the same proportion of the foliage from each plant grazed regardless of degree of grazing up to approximately 70 percent; however, there is a marked difference in the numbers of plants grazed at different levels of utilization (fig. R-5). The average herbage removal from individual grazed plants of 3 grasses was 59 percent, ranging from 57 to 64 percent in the 6 pastures. Fourteen percent of the individual plants were grazed under light use, 27 percent under moderate, and 56 percent under heavy grazing.

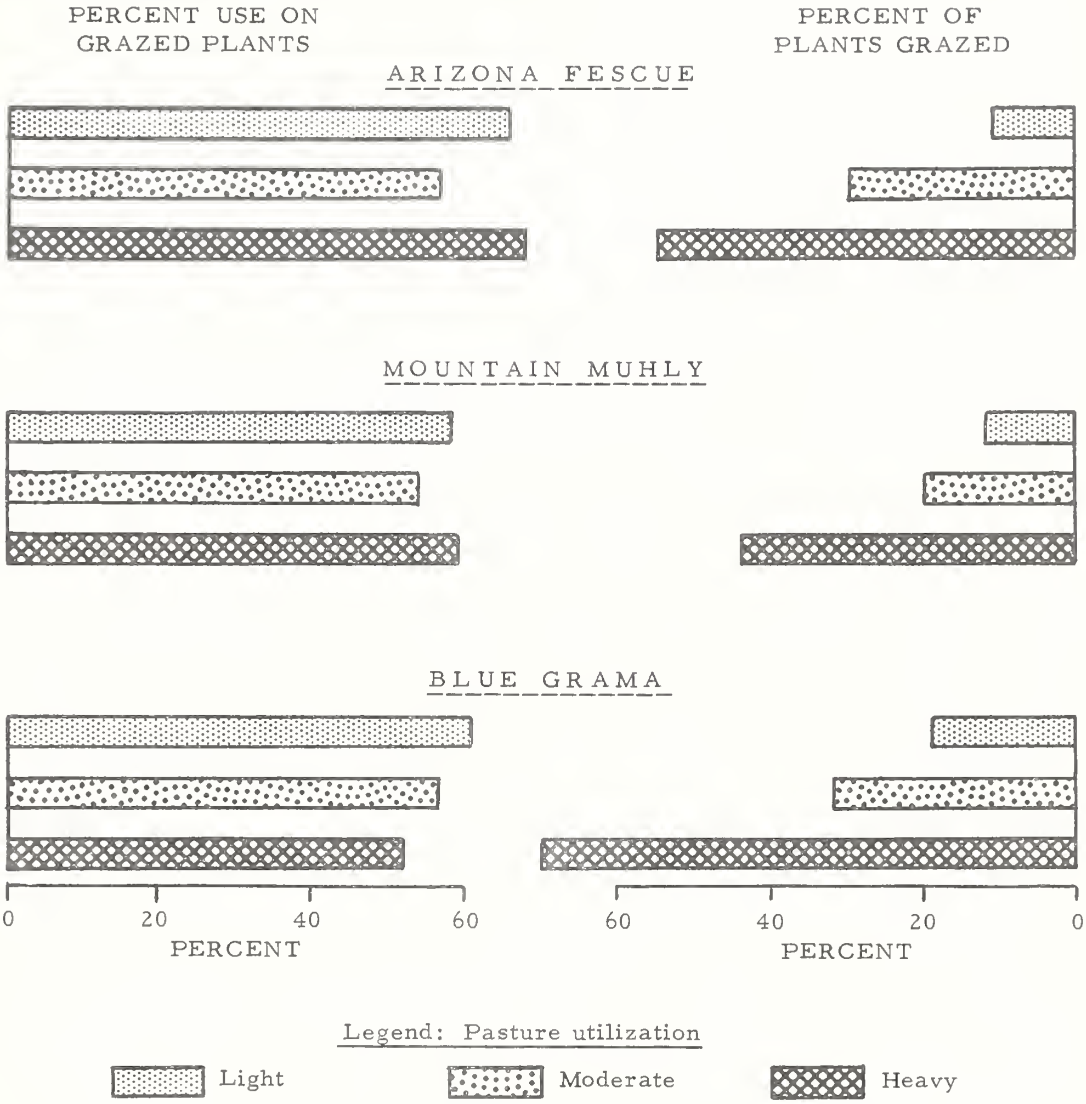


Figure R-5. --Relationship between utilization on grazed plants and the percentage of plants grazed under three intensities of grazing on ponderosa pine-bunchgrass ranges, Manitou Experimental Forest, Colorado.

Grazed-plant method appears usable for estimating utilization

As would be expected in view of the foregoing relationship, observations in 1957 showed a close relationship between percentage of plants grazed and percentage of herbage removed by cattle. This suggests that the grazed-plant method is adapted to the pine-bunchgrass ranges. As shown in figure R-6, different graphs are needed for Arizona fescue (Festuca arizonica), mountain muhly (Muhlenbergia montana), and blue grama (Bouteloua gracilis). Degrees of utilization of the three species for different percentages of plants grazed are as follows:

Plants grazed	Utilization		
	Arizona fescue	Mountain muhly	Blue grama
(Percent)	(Percent)	(Percent)	(Percent)
15	8	9	8
35	21	21	19
55	37	34	29
75	57	46	40

For each of the three species, the relationship was found to be similar for grassland and timber types.

Tree overstory reduces use by cattle

The tree overstory at Manitou Experimental Forest reduced the intensity of grazing on all major species. This is shown in Arizona fescue in the following tabulation; similar relationships of grazing intensity to cover type were also found for mountain muhly and blue grama:

Cover type	Percent of Arizona fescue plants grazed		
	Light use	Moderate use	Heavy use
Grassland	45	54	68
Open timber	10	30	63
Dense timber	6	14	36

Grassland is clearly most preferred by cattle, and dense timber least. With increased utilization, the percentage of plants grazed increased markedly in both open and dense stands of timber. Under heavy grazing, utilization in the open timber was nearly as much as in the grassland.

MOUNTAIN GRASSLAND RANGES

Pocket gophers eat, burrow, and breed under heavy snowpack

Pocket gophers are active under the snow from March until snowmelt, usually in June. Observations on Black Mesa in western Colorado during the past three winters have shown that as the snowpack deepens in late winter, the soil thaws and gophers begin to dig, both in the snow and in the soil.

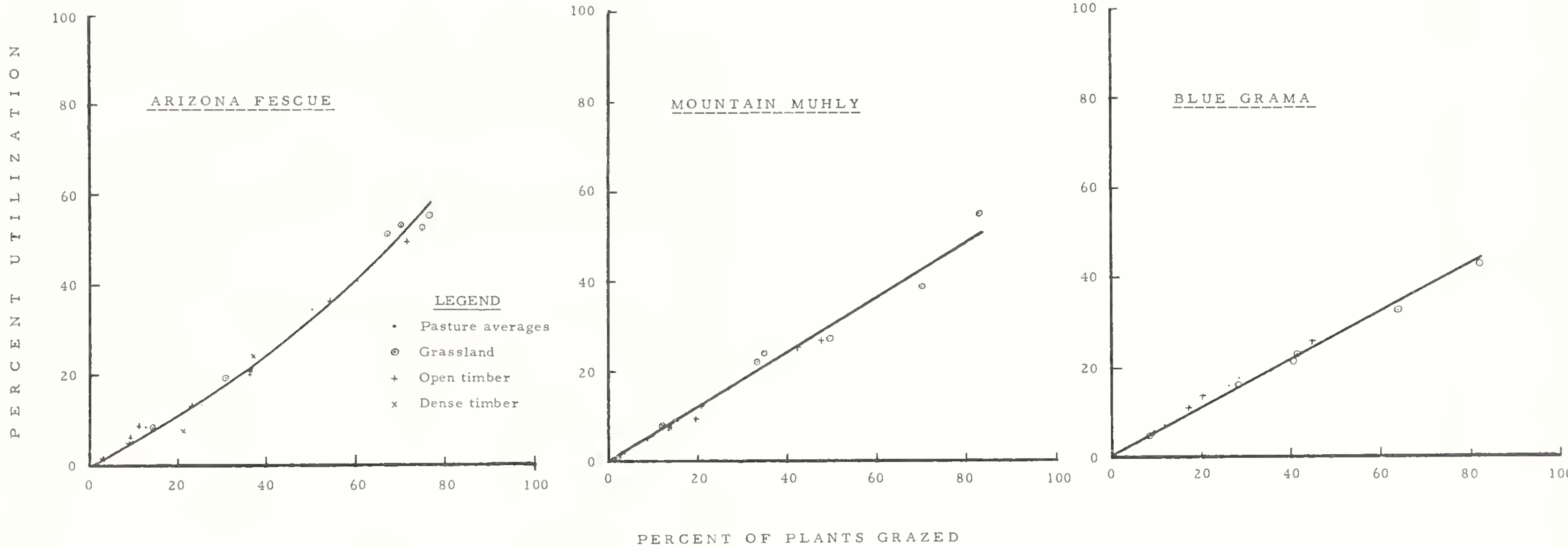


Figure R-6.--Relationship between percentage of plants grazed and percentage of utilization by weight for three grasses, Manitou Experimental Forest, 1957.

Excavated soil is packed into abandoned snow tunnels and after snowmelt this soil is left on the ground as long slender casts (fig. R-7). During three winters, casts have covered an average of 7.3 percent of the ground surface.

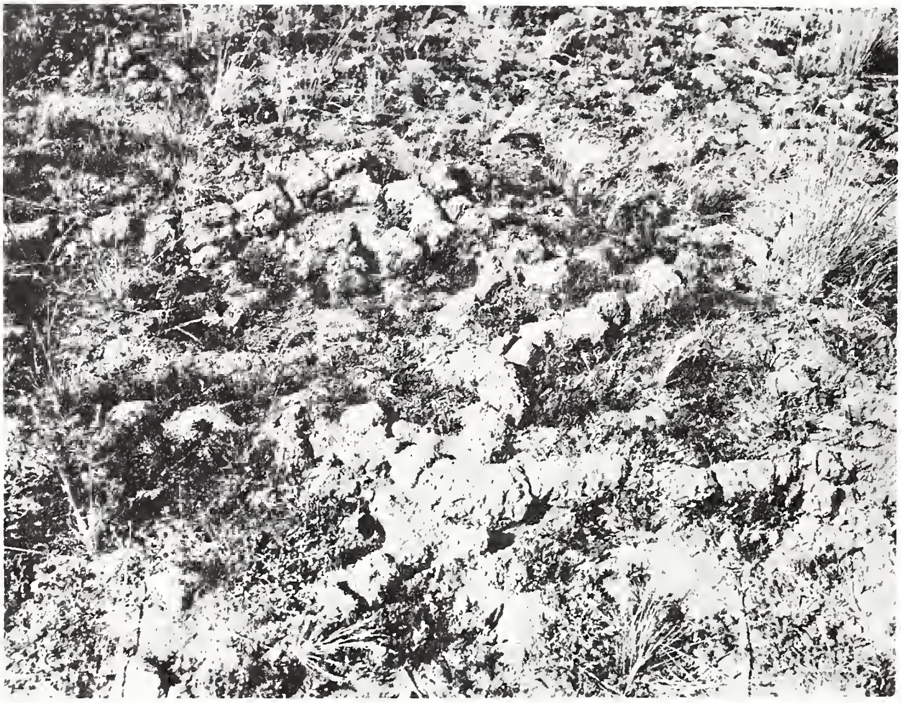


Figure R-7.--Soil casts, which remain after snowmelt, are formed as gophers fill tunnels in the snow with soil from underground runways.

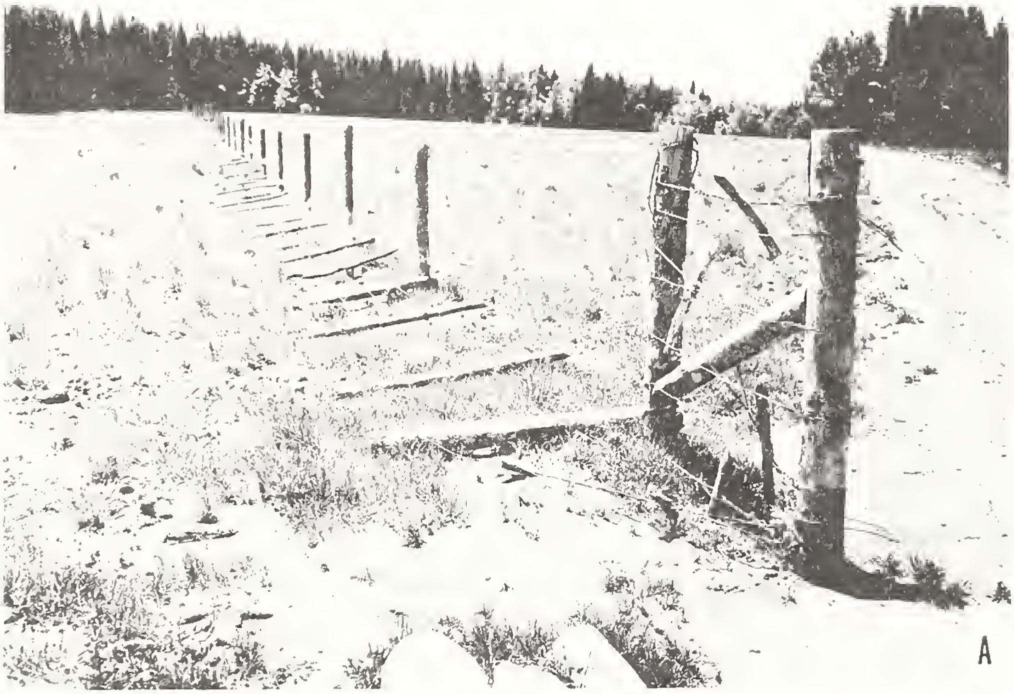
From November through February the animals are relatively quiet within their burrows. At that time, snow is usually 1 to 3 feet deep. Because surface soil is frozen, it inhibits digging. The gopher's main foods during this period are forb roots that are probably obtained from food caches.

During snowmelt gophers may move their nests and food caches into the snow to avoid wet soil or drowning. The animals remain above ground until their nests are exposed near the end of the snowmelt period when they take the dry nest material and their food caches back underground. Apparently some animals remain in the ground throughout this period but many perish during snowmelt. This is probably the most difficult time of the year for the gophers.

Gophers also breed under the snowpack and sometimes bear young in nests in the snow. On Black Mesa they breed once each year from late April through June. Young are born from late May through July. Litter size varies from 2 to 6 and averages 3.5 young per litter.

A laydown fence for snow country

Where damage from snow is severe on standard wire fences, a laydown fence as shown in figure R-8 has reduced maintenance costs by two-thirds on Black Mesa in western Colorado. Basically it is a standard 4-wire fence that can be laid down as a unit. One man can let it down or put it up almost as fast as he can walk.



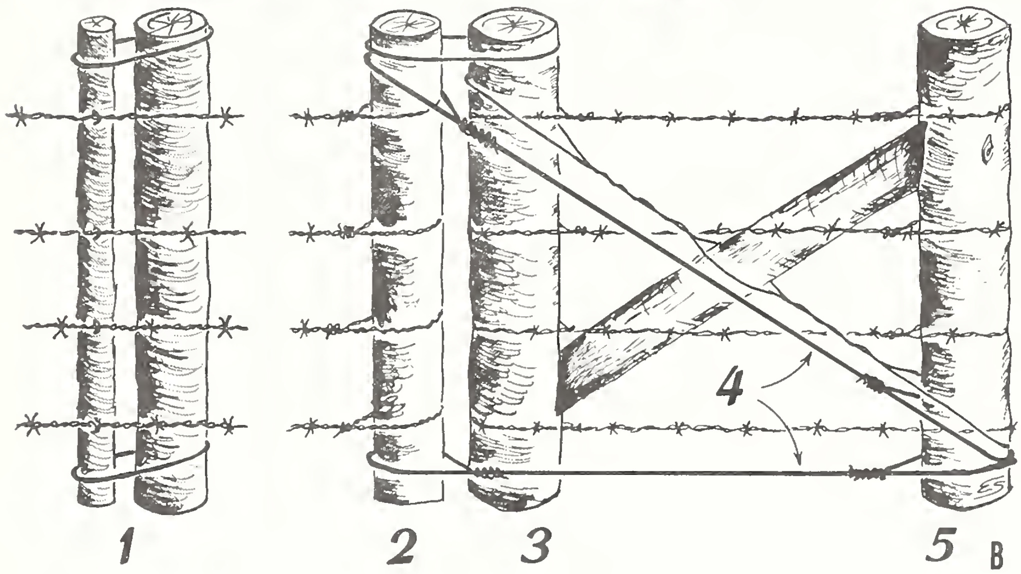


Figure R-8.--A, A laydown fence on the ground remains under tension but practically eliminates damage from snow; B, Construction detail of laydown fence showing: (1) stay slightly offset from line post, (2) stub post, (3) first brace post, (4) guy wires, and (5) second brace post.

Heavy grazing by elk reduced grass production

Grass and sedge herbage increased from 348 pounds per acre air-dry in 1955 to 1,511 pounds in 1958 on an area in northwestern Wyoming protected from elk and livestock (fig. R-9). On adjacent areas, one open to both elk and cattle, and the other open only to elk, herbage production increased, but less than on the area closed to all grazing.

Elk used much more of the herbage during the winter than cattle did during the preceding summer. Utilization averaged 25 to 30 percent in the spring after summer grazing by cattle and winter grazing by elk, compared with 2 percent in the fall when cattle left the area.

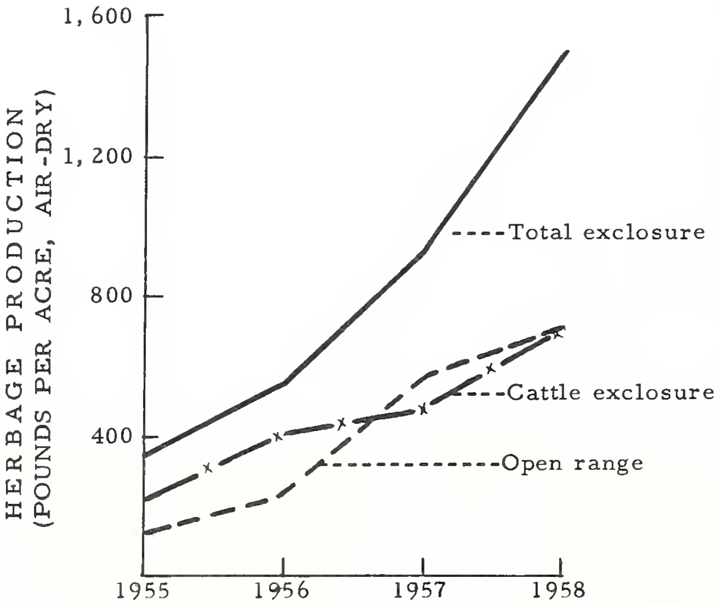


Figure R-9. --Production of grasses and sedges as related to grazing by elk and cattle.

IMPROVED SAGEBRUSH AND JUNIPER RANGES

Sagebrush understory --
bunchgrasses or sodgrasses?

Much of the herbaceous vegetation on sagebrush ranges at lower altitudes in Wyoming consists of such species as thickspike and western wheatgrasses (*Agropyron dasystachyum* and *A. smithii*), plains reedgrass (*Calamagrostis montanensis*), and needleleaf sedge (*Carex eleocharis*). These are all rhizomatous species. In contrast, bunchgrasses such as bluebunch wheatgrass (*Agropyron spicatum*), prairie Junegrass (*Koelaria cristata*), Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread (*Stipa comata*), and the small bunch bluegrasses (*Poa* spp.) are often sparse.

A study on Beaver Rim near Lander, Wyoming, showed that the bunchgrasses should be more abundant and indicated the potential that management of low-altitude sagebrush ranges might attain.

In an exclosure fenced against cattle grazing in 1951, the yield of sodgrasses (including needleleaf sedge) decreased rather consistently from 1951 to 1956 and then increased to 1958 (fig. R-10). Yields of bunchgrasses increased almost constantly during the 1951 and 1958 period. Spraying to control big sagebrush (Artemisia tridentata) seems to have been less important in producing these changes in species than the period of rest from grazing.

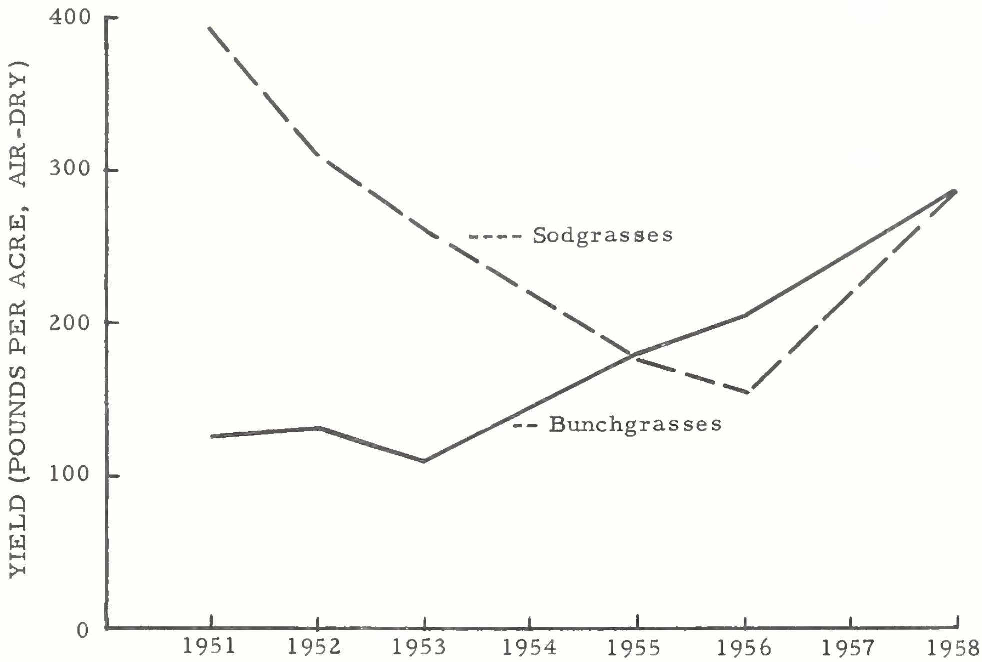


Figure R-10. --Comparative yields of sodgrasses and bunchgrasses on range near Lander, Wyoming, where sagebrush was chemically controlled and grazing was excluded.

Seeding deteriorated rangeland to crested wheatgrass pays dividends

Forage yield can be increased to supply 1 month of grazing by cattle in the spring on 2.5 to 7 acres of crested wheatgrass (Agropyron cristatum) range as against 35 to 70 acres of unseeded big sagebrush range in northern New Mexico (fig. R-11). When measured as a difference in return to capital investment in the ranch business, crested wheatgrass range grazed at 7 acres per cow-calf month had a value varying from $2.83 to $4.18 per cow-calf month of grazing above that of low-producing sagebrush range.

On favorable sites crested wheatgrass can be grazed at a rate of 2 to 3 acres per animal-unit month. Grazing these seeded ranges instead of native range resulted in an increased return to capital investment of $23.65 per animal-unit for cow-calf production. Likewise, holding good quality calves for sale as yearlings and grazing yearlong on crested wheatgrass showed a return of 7.2 percent on capital investment compared with 4.1 percent for cow-calf production.

Figure R-11.--

A, Native sagebrush range in northern New Mexico in the 14- to 15-inch precipitation zone produces about 50 pounds of grass herbage per acre;

B, Seeded range in the same area produces 600 to 1,400 pounds of crested wheatgrass herbage per acre.

These and other economic data on crested wheatgrass range are presented in New Mexico Agricultural Experiment Station Bulletin 433, "Economic Evaluation of Seeding Crested Wheatgrass on Northern New Mexico Rangeland." The evaluation was prepared cooperatively with the New Mexico Agricultural Experiment Station, as a sequel to Bulletin 413, "Cost of Seeding Northern New Mexico Rangelands."

Nutritive value of crested wheatgrass high

Though crested wheatgrass can be grazed yearlong by cattle, the maximum feeding value--total protein and total digestible nutrients--is obtained in the spring. In northern New Mexico, foliage samples collected in May contained 24 percent more digestible protein than alfalfa hay (fig. R-12). Percent crude

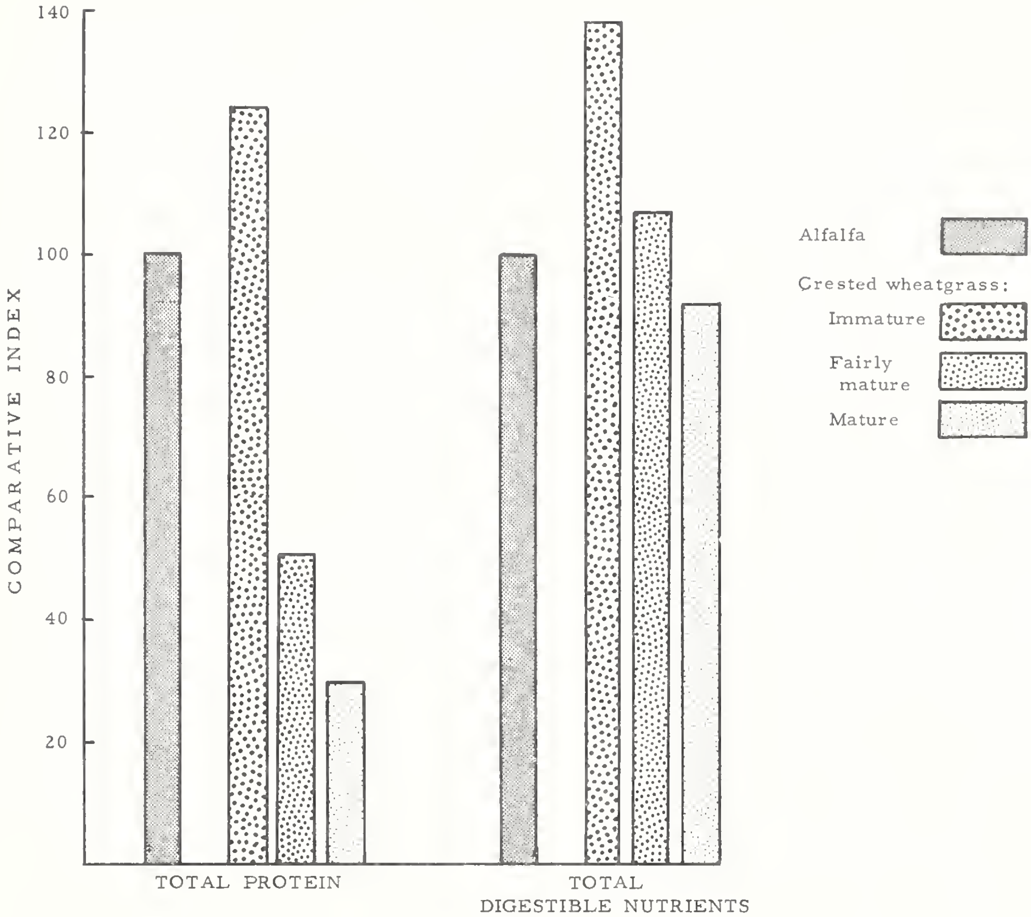


Figure R-12. --Nutritive value of crested wheatgrass at different stages of maturity compared with alfalfa hay, northern New Mexico.

protein and total digestible nutrients both decreased as the grass matured. By fall, protein was slightly less than one-third that of alfalfa; total digestible nutrients were about 92 percent. These results are from cooperative studies with the New Mexico Agricultural Experiment Station.

Heavy stocking of crested wheatgrass range for short spring period is warranted

Because crested wheatgrass yields fluctuate widely with variations in amount and distribution of annual precipitation, degree of use that may be obtained on spring range will vary from year to year. Even with early estimates of forage yield and records of precipitation to assist in estimating total forage production, percent utilization actually obtained at two experimental sites in northern New Mexico varied widely, as shown in the following tabulation:

Utilization objective	Utilization obtained: Cebolla Mesa site (1952 through 1958)	Utilization obtained: No Agua site (1955 through 1958)
	- - - - (Percent) - - - -	
Heaviest grazed (75 percent)	49 to 81	70 to 83
Medium grazed (50 percent)	41 to 68	38 to 76
Lightest grazed (25 percent)	20 to 57	27 to 42

However, at Cebolla Mesa, spring grazing for 1 month within the range of 49 to 81 percent utilization over the 7-year period has not lowered herbage yields. Neither has spring grazing at the heaviest rate affected yields on the No Agua site. Thus, a stocking rate that will utilize the crested wheatgrass herbage within these limits under spring grazing seems acceptable.

Crested wheatgrass provides good lambing range

For 2 years lambing on crested wheatgrass range in northern New Mexico has given better daily gains of lambs than lambing on adjacent native range. Pregnant ewes from a band were placed under 3 conditions during the lambing period: twelve 5-acre paddocks of crested wheatgrass; a 200-acre crested wheatgrass range; and adjacent ponderosa pine and pinyon-juniper-sagebrush range. Sheep were under the supervision of a herder on the seeded range and the native range. Grazing was from May 16 to July 2 in 1957 and from May 1 to June 24 in 1958. Average daily gain of lambs varied as follows:

Lambing range and grazing intensity	Daily gains: 1957	Daily gains: 1958
	- - (Pounds) - -	
5-acre paddocks of crested wheatgrass:		
Very light	0.63	0.66
Light	.61	.59
Medium	.59	.65
Heavy	.55	.54
Unfenced crested wheatgrass:		
Medium	--	.67
Native range (2,000 acres, unfenced, in 1957; 80 acres, fenced, in 1958. Ewes and lambs were placed on native range after lambs were dropped between May 1-23):		
Light	.52	.55

Ewes on heavily stocked paddocks spend more time grazing

Ewes on heavily grazed crested wheatgrass range spent more time grazing than ewes on more lightly grazed range. Observations on time spent grazing on experimental paddocks in northern New Mexico indicated that ewes on lightly stocked range obtained their "fill" of forage more rapidly in the early morning period. Ewes on the heavily stocked paddocks needed additional time to consume the necessary amount of forage (fig. R-13). The greatest number of ewes grazed in early morning, late afternoon, and evening. Nearly all ewes were observed as early as 5:20 a.m.; the fewest grazed between 7 a.m. and 8 a.m., and around noon.

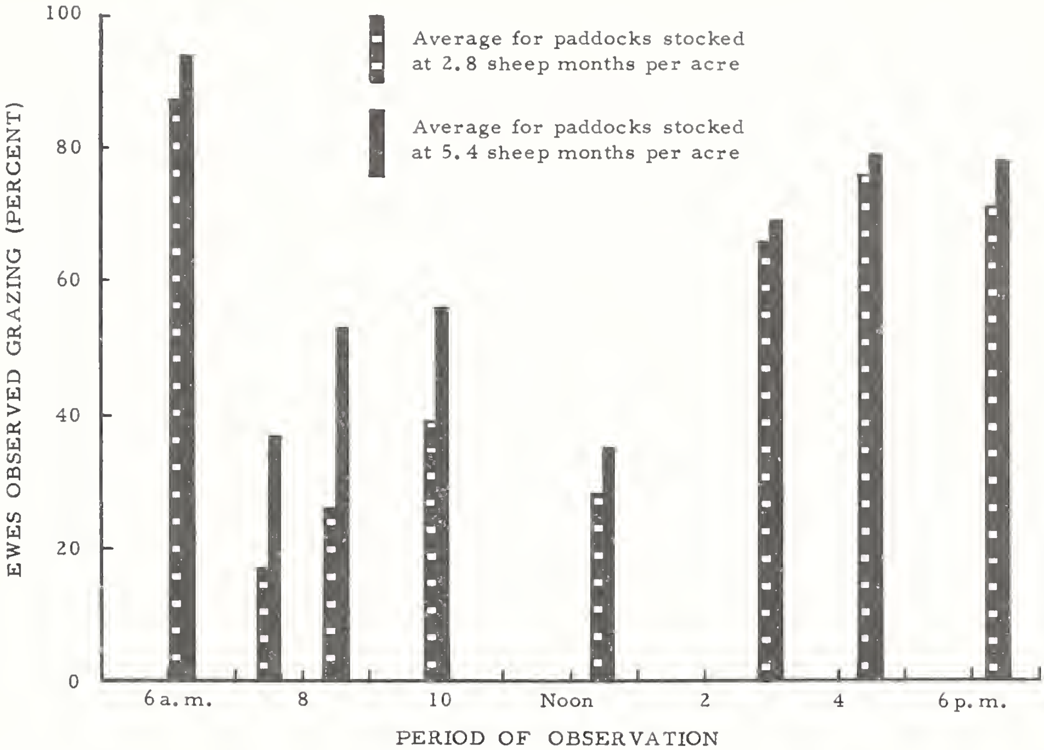


Figure R-13. --Comparisons of ewes grazing during different periods of the day on paddocks stocked at two rates on spring lambing range, Tank Canyon, northern New Mexico.

WOODLAND AND CHAPARRAL RANGES

Shrubs reestablish faster than forbs or grass on Mingus Mountain burn

By the third growing season, vegetation on Mingus Mountain burn in central Arizona had become reestablished to the point that shrubs produced 2,200 pounds, forbs 560 pounds, and grasses 140 pounds, green weight, per acre (fig. R-14). Eighty percent of the shrubby vegetation was shrub live oak (*Quercus turbinella*). The principal forb, which was more abundant on burned than on unburned sites, was Palmer penstemon (*Penstemon palmeri*). Native grasses produced 80 pounds per acre, while seeded grasses--weeping lovegrass (*Eragrostis curvula*) and crested wheatgrass together produced 60 pounds per acre. Crown cover of all shrubs was 11 percent 4 months after the fire, and after the third growing season was 27 percent. This is approximately half that which existed prior to the burn.

Both deer and cattle graze burned range

During the winter of 1957-58 on the Mingus Mountain burn, deer used 55 percent of the annual growth of Wright silktassel (*Garrya wrightii*), 35 percent of mountainmahogany (*Cercocarpus breviflorus*), and a trace of shrub live oak and grass. Cattle used the burned area beginning in 1958. At the end of the 1958-59 winter, cattle and deer together had used 25 percent of the annual growth of Wright silktassel, 20 percent of mountainmahogany, a trace of shrub live oak, 2 percent

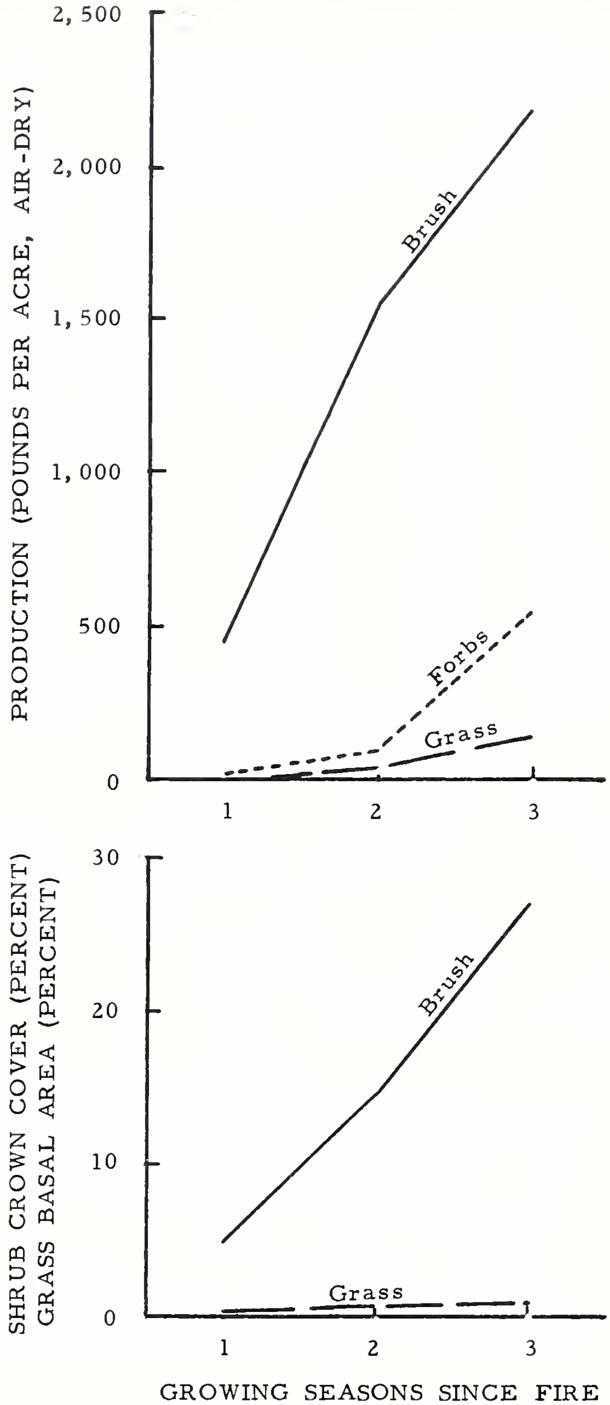


Figure R-14. -- Vegetation is recovering rapidly after a wildfire on Mingus Mountain in central Arizona, as shown by annual measurements of herbage production and cover.

of forbs, and 10 percent of grasses. Approximately half the grass use and a small amount of browse use occurred during the summer of 1958. Observations on a more recently burned area show that somewhat greater use of shrub live oak sprouts is made by cattle where they were permitted to graze the first year following burning.

Burning favors establishment of manzanita seedlings

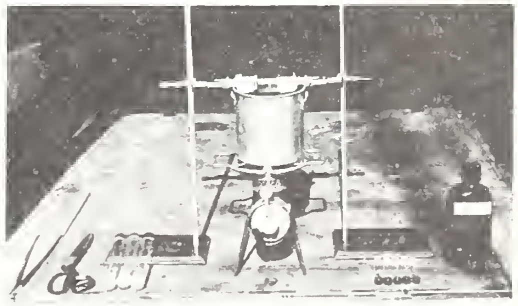
Domination of a chaparral site by pointleaf manzanita (Arctostaphylos pungens) is apparently complete and continuous, even following a fire that kills all living stems. Within the periphery of the dense crown of mature plants there is usually little else but a heavy cover of litter and dormant seeds from the parent plant. After a fire, which scarifies the seeds, pointleaf manzanita seedlings rapidly become established in great abundance to the exclusion of most other plants (fig. R-15). Observations on the Mingus Mountain burn show that pointleaf manzanita, a non-sprouting component of the chaparral complex of central Arizona, although easily killed by fire, is not replaced by other species.

Figure R-15.--Reproduction of pointleaf manzanita following a burn. After a fire, which scarifies seeds of pointleaf manzanita, seedlings quickly reoccupy the same site. Vegetation in the background is principally sprouts of shrub live oak.

Heat resistance of grasses greatest in winter

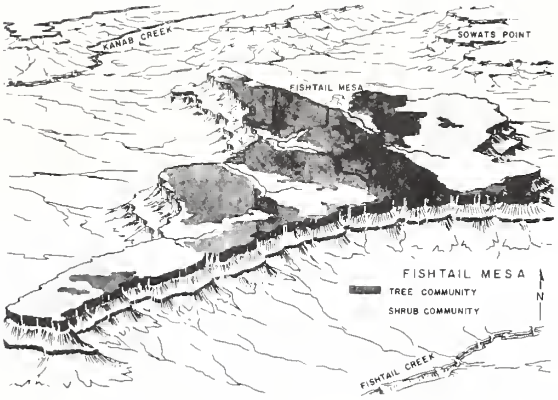
The critical lethal temperatures of meristematic tissue of plants in the pinyon-juniper type were generally highest in the winter and lowest in May and June. The differences in critical temperatures between the periods for grasses, including galleta (Hilaria jamesii), blue grama, black grama (Bouteloua eriopoda), and side-oats grama (B. curtipendula), average about 10°C. Tissues of grasses were more sensitive to heat than were tree tissues. Alligator juniper (Juniperus deppeana) and pinyon (Pinus edulis) were more resistant to higher temperatures than one-seed (J. monosperma) and Utah junipers (J. osteosperma). These determinations were made as part of a study to determine the period when the grasses are most resistant to heat and least likely to suffer damage while burning the juniper overstory (fig. R-16).

Figure R-16.--Field apparatus used to test heat and desiccation resistance of plant tissue. Tissue was placed in the test tubes, which were placed in boiling water until the desired temperatures were reached inside the tubes. Tetrazolium chloride was used to determine whether tissue was killed. Recovery of treated tissue in the greenhouse substantiated the reliability of the tetrazolium chloride test for viability.



Vegetation on ungrazed mesa in Grand Canyon shows little difference from grazed mainland

Big sagebrush, pinyon, and Utah juniper made up about 88 percent of the plant cover of an area that has never been grazed by domestic livestock (fig. R-17). These species are also dominant on many areas surrounding the rim of the Grand Canyon that have been subjected to livestock grazing for many years.



A, Fishtail Mesa is isolated by a sheer escarpment around its perimeter;

B, Pinyon-juniper type is found on 74 percent of the area;

Figure R-17. --Location of Fishtail Mesa in the Grand Canyon and appearance of major vegetation types.

Other woody plants accounted for most of the rest of the cover. Longtongue mutton bluegrass (Poa longiligula) was the most common herbaceous species but made up only 0.2 percent of the cover. Blue grama, which is common on similar areas grazed by domestic livestock, made up 0.5 percent of the cover on rocky ridges but was generally lacking elsewhere on the mesa.

C, Sagebrush is the major species in the shrub type;

D, Following fire, pinyon-juniper type has been converted to sagebrush.

Vegetation on winter range in western Colorado slow to change

After being fenced, major components of plant and ground cover changed very little from 1953 to 1958 on Badger Wash Experimental Watersheds in the salt-desert shrub type in western Colorado. In 1953, four watersheds were fenced to exclude livestock, while four comparable areas continued to be grazed by both sheep and cattle during winter months. As shown in table R-1, bare soil and rock (erosion pavement) made up about three-fourths of the ground surface in 1953 (fig. R-18). Remeasurements 5 years later showed that there had been practically no changes in vegetation or ground cover on either the grazed or ungrazed watersheds.

Table R-1. --Change in ground cover on Badger Wash Experimental Watersheds, 1953-58 (averages for four grazed and four ungrazed watersheds)

Item	Grazed			Ungrazed		
	1953	1958	Difference	1953	1958	Difference
	Percent					
Bare soil and rock	75	78	3	79	77	-2
Litter	20	18	-2	17	20	3
Plant density index	4.5	3.6	-0.9	4.0	3.7	-0.3
Overstory shrubs	12	10	-2	14	15	1
Ground cover index	30	26	-4	27	29	2

Figure R-18. --Plant and ground cover, as recorded by the loop method, remains sparse on Badger Wash watersheds after 5 years' protection from livestock.

Increased grass production following mesquite control still high 14 years after treatment

Up to 10 times more perennial grass herbage was produced in 1958 on plots cleared of mesquite (Prosopis juliflora var. velutina) in 1945 than on adjacent uncleared plots on the Santa Rita Experimental Range in southern Arizona (fig. R-19).

Figure R-19.--A, Sparse understory of perennial grasses beneath unthinned stand of mesquite; B, Adjacent area thinned to 9 mesquites per acres, with 5.5 times as much perennial grass herbage per acre.

Mesquite was thinned to 25, 16, 9, and no trees per acre on plots at each of 4 elevations in 1945. Uncleared plots averaged 44 mesquites per acre at the lowest elevation and 358 per acre at the highest elevation. Lehmann lovegrass (Eragrostis lehmanniana) was seeded in a narrow strip across one end of each plot.

The greatest response of the grass to mesquite thinning was at the 4,100-foot elevation on plots cleared of mesquite (fig. R-20). Herbage yields on plots at this elevation on which mesquite was thinned, were intermediate between the cleared and the uncleared check plots. At lower elevations, the effects of mesquite thinning on herbage production were less pronounced but in general there was less grass production with decreasing elevation and increasing numbers of trees.

The Lehmann lovegrass seedings were more successful at the higher elevations. As shown in the tabulation below, herbage production by lovegrass in 1958 at 4,100 feet was 50 percent higher than that of the native perennial grasses. At lower elevations, herbage production of lovegrass was lower than that of native grasses.

Elevation	Native perennial grasses	Lehmann lovegrass	Mean
(Feet)	- - - - (Pounds	per acre) - - - -	
4,100	332.2	518.7	425.5
3,900	350.4	251.7	301.1
3,600	124.7	31.5	78.1
3,300	81.8	4.1	43.0
Mean	222.3	201.5	211.9

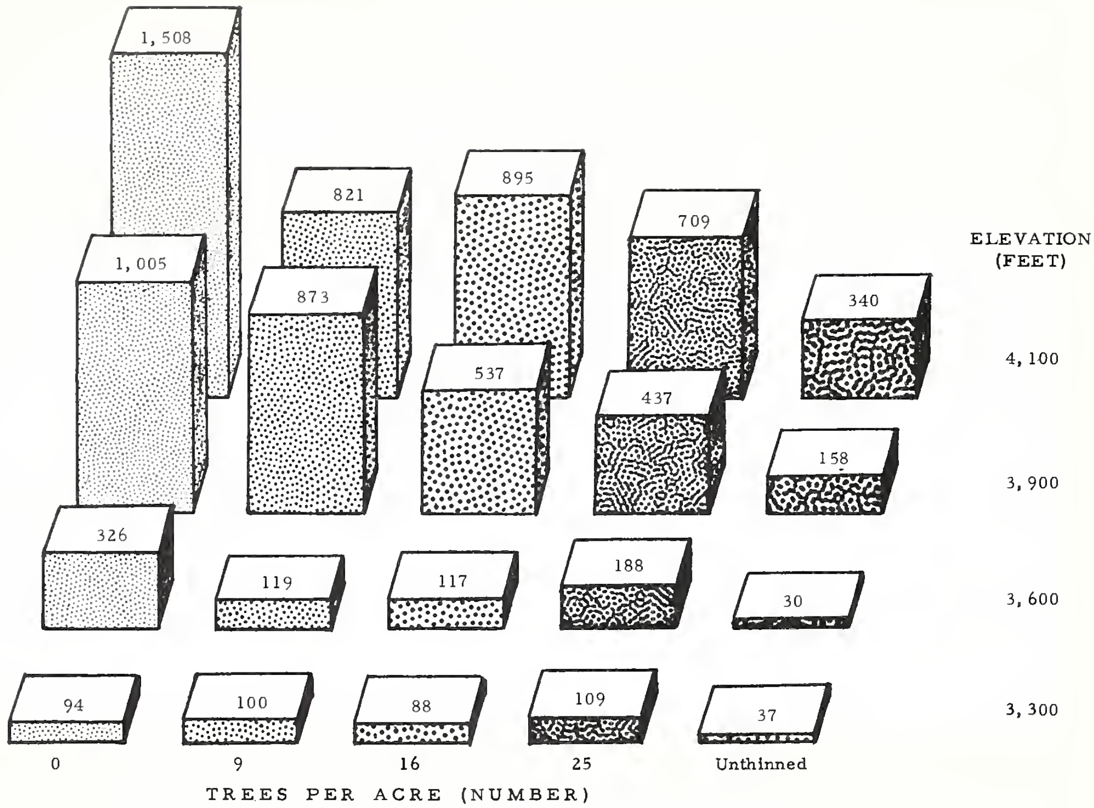


Figure R-20. --Perennial grass herbage in pounds per acre, air-dry, produced in 1958 on plots with various numbers of mesquite trees and different elevations.

Burroweed control of doubtful value if followed by heavier grazing

Burroweed (Aplopappus tenuisectus) control without adequate management of cattle usually results in an increase in low-value annual grasses and a decrease in perennial grass production on southern Arizona rangelands because burroweed-free areas are usually grazed more closely than are burroweed-infested areas (fig. R-21). The beneficial effects of removing burroweed often are offset by the harmful effects of close grazing. Increases in perennial grasses have been recorded following burroweed removal only on plots that were protected from grazing.

Many control methods have been tested on burroweed. Burning in late spring or summer, when there is ample herbage to carry a fire, is probably the cheapest and most effective method. Following burning, the grasses must be given a chance to recover from the fire. If the rate of stocking is not adjusted to a level that will permit the grasses to reproduce themselves, burning may do more harm than good, even if it kills all the burroweed.

Of other methods, hand grubbing is effective but expensive. Close mowing is reasonably effective during the late spring and early summer; however, much burroweed range is too rough or too brushy to mow. The ester of 2,4-D appears most promising as a chemical control but results have been erratic.

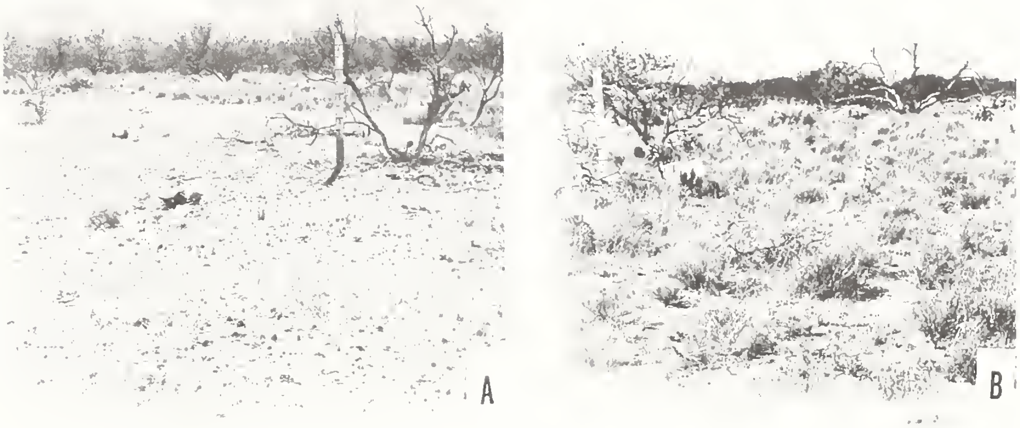


Figure R-21.--A, Burroweed-free plot shows close use of perennial grasses by cattle only 2 months after the end of the growing season; B, Burroweed-infested range nearby shows practically no use.

Important facets of burroweed ecology

Because it is poisonous to cattle and horses and competes with important forage plants burroweed has been considered a problem on southern Arizona rangelands. Conclusions derived from studies of its life history are: (1) Burroweed germinates in the cool winter and spring rainy season, but seedlings suffer high mortality in the April to June dry period; (2) in southern Arizona, burroweed is most abundant between 2,000 and 5,000 feet, on noncalcareous soils; (3) on the Santa Rita Experimental Range where most of the burroweed studies have been made, burroweed apparently made its most rapid spread from 1900 to around 1930 or 1935. Since that time, many of the older stands have decreased in density; (4) reasons for the increases in burroweed on grassland are probably associated with changes in the amount and distribution of rainfall, grazing, and changes in the incidence of range fires.

Winter precipitation important in summer growth of perennial grasses on semidesert range

Perennial grasses on the Santa Rita Experimental Range decreased markedly from 1953 to 1956 and partially recovered in 1957 and 1958, apparently in response to winter-spring precipitation received (fig. R-22). Precipitation during 1951 and 1952 was 66 percent above average for the winter-spring periods; summer rainfall was about average in 1951 but only 75 percent of average in 1952. In the next four consecutive years, 1953 through 1956, winter-spring precipitation averaged 11 to 18 percent below the longtime average. Summer rainfall was above average for 1954 and 1955 and also for 1957 and 1958.

The basal intercept of most perennial grasses began to decrease in 1953, when both winter-spring and summer precipitation were below average. The decline in basal intercept continued during the 1954 and 1955 growing seasons, when winter-spring precipitation was below average, even though summer rainfall was

well above average in both summers. Grass cover was lowest in the fall of 1956 following deficient rainfall both in the winter-spring and summer periods. The grasses again increased in 1957 and 1958 when above-average summer rainfall was preceded by average or above-average winter-spring precipitation.

Among species, Rothrock grama (Bouteloua rothrockii) appeared to be affected less by winter-spring precipitation than the other perennial grasses such as Santa Rita three-awn (Aristida glabrata), three-awn (Aristida spp.), Arizona cottontop (Trichachne californica), and tanglehead (Heteropogon contortus). In 1954, a year of high summer but low winter-spring rainfall, Rothrock grama maintained a relatively high basal intercept, while basal intercepts of the other species decreased sharply. This reaction is not surprising because Rothrock grama is a very short-lived perennial that often responds to rainfall almost like a summer annual.

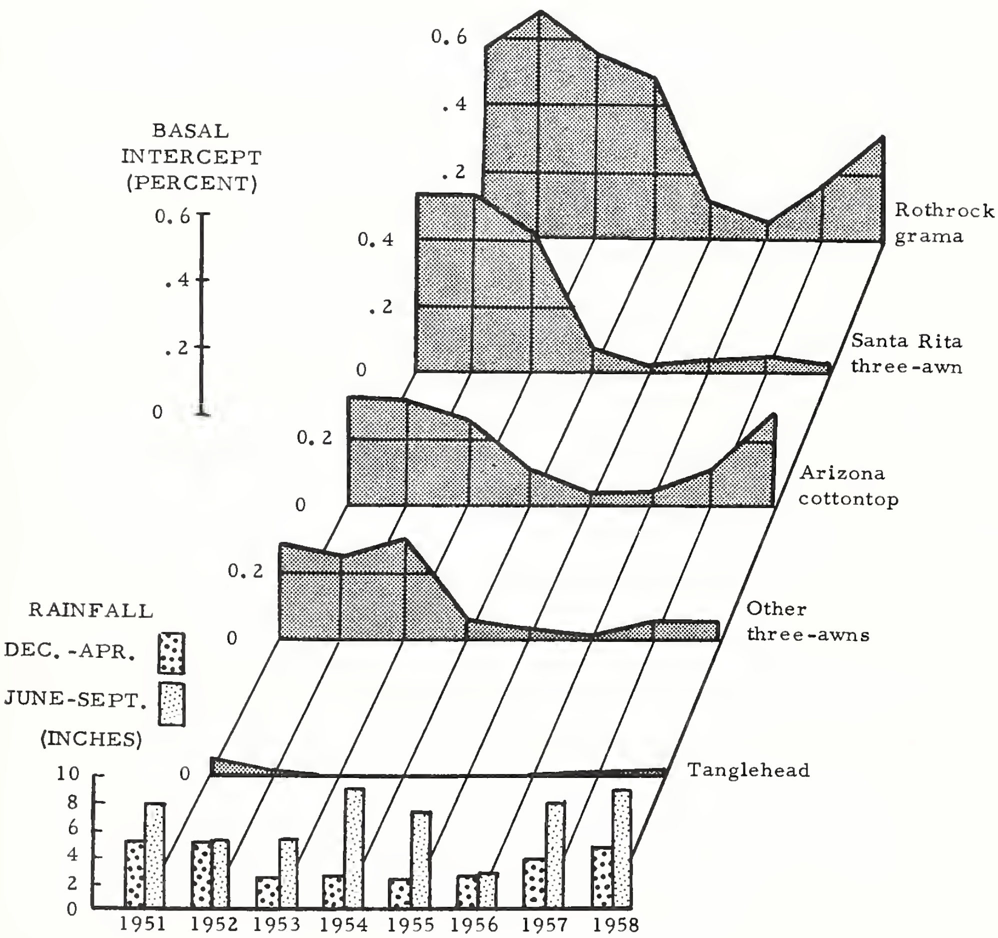


Figure R-22. --Relation of change in basal density of perennial grasses to the amounts of winter-spring precipitation received prior to the growing season, Santa Rita Experimental Range, 1951-58.

FOREST BIOLOGY

(In cooperation with U. S. Fish and Wildlife Service)

Pocket gopher trends on experimental rangelands in Colorado

Inventory work in the six Thurber fescue (*Festuca thurberi*) pastures on the Black Mesa experimental area in western Colorado showed a sharp reduction in pocket gopher population in 1959. Seventy-eight percent of 120 permanent plots had fresh pocket gopher mounds in September 1958; only 22 percent had new mounds in 1959. Thus, burrowing showed a 56-percent decrease. Likewise, there was an 85-percent decrease in the number of new mounds appearing on these plots in 1959. The cause of the decline was not apparent but pocket gopher trapping studies indicated that few young animals were produced in 1959. They composed only 14 percent of the fall population; whereas, in 1958 and earlier years about 75 percent of the population was made up of young.

The amount of dirt moved to the surface by pocket gophers in the form of dirt cores in the winters of 1958 and 1959 was about the same. The casts were tallied along permanent transect lines each year soon after snowmelt to study the trend in pocket gopher populations on the pastures (see fig. R-7, page 10). The cast count indicated no major change between the early spring of 1958 and the spring of 1959. The population presumably declined sometime between the 1959 cast count and the fall mound tally in the period when the surge of new young would normally appear in the population.

The reduction in the gopher population, as determined by the mound counts, was apparent in all six pastures irrespective of the light, moderate, or heavy grazing treatments.

Thus, the pocket gopher decline on Black Mesa followed by 1 year the population low reported in 1958 for the Grand Mesa mountain rangeland northwest of Black Mesa.

Although some reduction in population was noted in the experimental pastures on ponderosa pine-bunchgrass range at Manitou Experimental Forest on the Colorado Front Range, the drop was not as marked as that registered for Black Mesa. At Manitou, different grazing treatments have been in effect beginning in 1941. Fresh mounds were found on 12 percent of the permanent plots used to sample the areas in 1958, and 7 percent in 1959. The number of new mounds found on the plots over a 48-hour period decreased from 22 in 1958 to 12 in 1959.

A similar mound tally in the ungrazed 2.5-acre exclosures in the experimental pastures at Manitou showed more gopher activity there than in the pastures grazed lightly, moderately, and heavily by cattle. This difference was

expressed in the percentage of plots occupied by fresh mounds and in the number of new mounds thrown up over a 48-hour period. It suggests that, on this type range, nonuse on the 2.5-acre exclosures favors pocket gopher populations, while grazing sufficiently alters the plant community in a way that holds the gopher population at a somewhat lower level.

Mouse-population studies on Black Mesa pastures continued

The population of meadow and whitefooted deer mice on the six Black Mesa experimental pastures, although higher than registered during the low year of 1957, showed no marked change in 1959 from that of 1958. The population highs found on the pastures in 1954 and 1956, 14.6 and 20.8 animals, respectively, have not been repeated in the last 3 years. The rodent inventory work is being done on the Thurber fescue summer rangelands at Black Mesa to determine whether various grazing treatments have any influence on the small rodent population. The pastures were grazed as nearly alike as possible during the calibration period from 1954 through 1956. Actual grazing treatments began in the summer of 1957. At this early stage in the grazing treatments it appears that the mouse population on the heavily grazed pastures is being held at a slightly lower level than in those that are moderately or lightly grazed. The comparison of number of mice caught per 100 trap nights by intensity-of-use pastures during the calibration period and the grazing-treatment period is as follows:

	Light	Moderate	Heavy	Average
	- - - - - (No. of mice) - - - - -			
Calibration period:				
1954	12.8	11.1	20.0	14.6
1955	--	--	--	--
1956	15.0	19.2	28.3	20.8
Treatment period:				
1957	1.7	1.1	1.1	1.3
1958	6.1	5.5	3.3	5.0
1959	5.1	7.5	3.2	5.4

Small mammal population remains low at Manitou

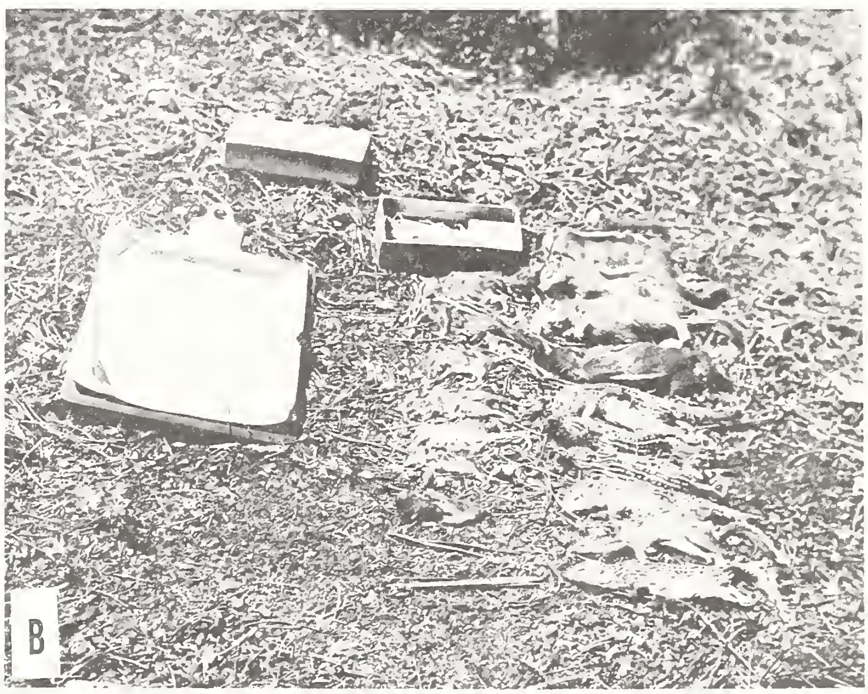
A comparison of the catch of whitefooted deer mice, meadow mice, thirteen-lined and golden-mantled ground squirrels shows that the population trend of these animals has remained low and relatively uniform over a 3-year period. The inventory work was done on the six native ponderosa pine-bunchgrass pastures at the Manitou Experimental Forest, where grazing treatments have been in effect since 1941. The catch of these animals per 100 trap nights by grazing treatment and years is as follows:

Intensity-of-use	1957	1958	1959
	- - - (Number) - - -		
Nonuse (cattle exclosure)	--	18.1	5.6
Light	5.0	4.7	2.8
Moderate	2.5	3.3	1.9
Heavy	3.6	2.5	1.7
Weighted average	3.7	3.5	2.1

The trend in the small rodent population has been for the exclosures to contain most animals, followed by the lightly grazed pastures, then the moderately and heavily used ones (fig. FB-1).

Figure FB-1.--One night's small rodent catch from inventory line, Manitou Experimental Forest.

A, In six cattle exclosures in experimental pastures. From bottom to top on clipboard: shrew, whitefooted deer mice, golden-mantled ground squirrel. On ground: meadow mice, one thirteen-lined ground squirrel (upper lefthand corner).



B, In each of the six experimental pastures. Left column, bottom to top: meadow mouse, whitefooted deer mice, chipmunks. Right column, bottom to top: Thirteen-lined ground squirrels, golden-mantled ground squirrels.

Seemingly, the more severely modified vegetative cover of the moderately and heavily grazed pastures creates a less favorable habitat for these four species of animals than does the less intensively or nonused areas. The fact that the number of these small mammals has remained low and relatively uniform over the 3-year period suggests that the grazing treatments have sufficiently changed the plant communities on the pastures so as to adversely influence the rodent population and keep them at a low level.

Deer use on Fraser watershed

More deer use, as determined by deer-pellet group counts, occurred in older cuts and uncut controls than in more recently harvested subalpine coniferous stands on the Fraser Experimental Forest. Two to four times as many deer-pellet groups were tallied on the uncut controls as on strips logged in 1954-56, and 2 to 10 times as many groups were found in the control as in the 6-chain strips cut in 1954-56 and 5-acre blocks cut in 1940. On this summer range, mule deer seem to prefer the unlogged stands and older cuttings, where better cover and possibly food conditions exist, to the more recently harvested areas.

The production of arnica and blueberry forage, recognized summer deer foods, was measured on the clear-cut strips and uncut controls. More arnica was produced in the 1954-56 cuttings than in the controls; whereas, there was no significant difference between the blueberry production on the logged and the untreated areas.

This 2-year study was conducted cooperatively with the College of Forestry and Range Management and the Colorado Cooperative Wildlife Research Unit of Colorado State University, and the Colorado Game and Fish Department. The investigation has laid the groundwork for future studies for evaluating the influence of various timber-harvesting methods on deer for this type summer range.

FOREST MANAGEMENT RESEARCH

Factors affecting windfall around clear cutting in spruce-fir

A survey of factors that influence windfall along the boundaries of clear cutting in spruce-fir forests indicates the following:

1. Twice as many windfalls per chain of cutting boundary have been found along leeward boundaries (wind blowing across the cutting unit to the uncut timber) as along windward boundaries (wind blowing from uncut timber to the cutting unit).

2. Windfalls have been just as numerous along boundaries that parallel the direction of the prevailing westerly and southwesterly winds as along boundaries perpendicular to the winds.

3. Windfalls have averaged about one for every 3 chains of cutting boundary on slopes facing the wind, and one for every 4 chains of boundary on slopes that face away from the wind.

4. Heavy windthrow has been found along cutting boundaries on ridgetops or in saddles on or near ridgetops. Fewer and approximately equal numbers of windfalls have been found on upper, middle, and lower slopes and along stream bottoms.

5. No material difference in number of windfalls has been found on slopes that differ in steepness from nearly level to more than 60 percent.

6. Cutting units in the lee of a saddle in a major ridge suffered above-average blowdown. The acceleration of winds that funneled through the gap caused concentrated blowdown along cutting boundaries exposed to the increased wind.

7. The amount of windfall showed a consistent relationship to size of opening. The number of windfalls was directly related to the length of cutting boundary perimeter exposed.

8. Lodgepole pine was found to be the most windfirm species, Engelmann spruce was least, and subalpine fir was intermediate. Open-grown trees were more windfirm than stand-grown trees; sparsely crowned stand-grown trees were more resistant than densely crowned stand-grown trees.

9. Localized pockets of windfall were found on soils having impeded internal drainage, but in general neither the internal drainage nor depth of soils correlated with frequency of windthrow.

10. Root and butt rots that weakened roots were associated with nearly one-third of all wind damage. All trees that broke off aboveground contained stem rot at the point of failure. Almost 27 percent of wind-damaged firs, 21 percent of the spruces, and 12 percent of the lodgepole pines were broken aboveground.

Weight of pulpwood in standing ponderosa pines can be estimated

The ovendry weight of pulpwood in Black Hills ponderosa pines can be estimated from their diameters and merchantable lengths. Weight gives a better estimate of potential yield than volume.

The ovendry weight of a bole below a top diameter of 4 inches inside bark can be determined in two ways. Tree volume obtained from a merchantable cubic-foot volume table can be multiplied by 24.8, which is the number of pounds of ovendry wood in a cubic foot of Black Hills pine. Alternatively, weight can be computed from the equation:

$$\text{Log } W = 1.4685 \log D + 1.0487 \log H - 0.7400$$

where

W = ovendry weight of the merchantable bole in pounds
D = diameter breast high in inches
H = merchantable length in feet

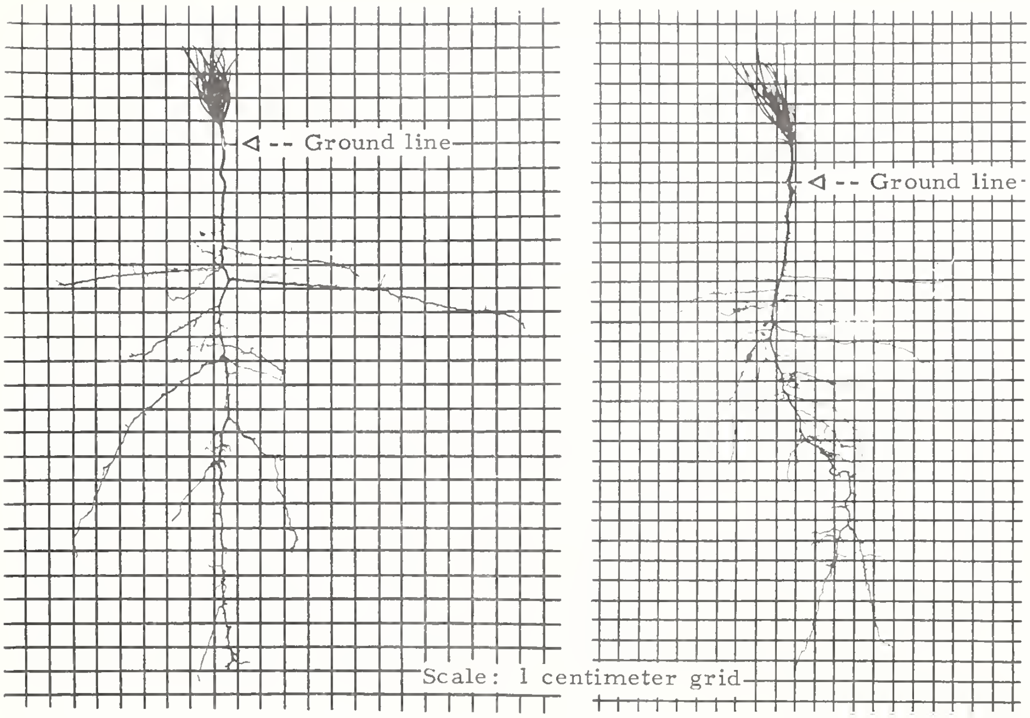
Either procedure can be used for immature trees 6.0 to 12.9 inches d.b.h. The relationships are valid for trees from thinned and unthinned stands and apply over a full range of stand densities and site indexes.

Root penetration of Black Hills ponderosa pine seedlings is increased by removing competing vegetation

Roots of ponderosa pine seedlings growing without competition of other plants penetrate a greater soil volume than those growing in competition with grasses and shrubs in the Black Hills. Seedlings were grown in vegetation-free plots and in seed spots where competing vegetation was not controlled on two burned areas, one with soil from metamorphic rocks and one with soil from limestone. The seedlings were washed out of the soil, and vertical and horizontal root penetration was measured.

Both taproots and lateral roots penetrated more on the weeded plots. In the limestone area, penetration was greater in 1 year on the weeded plot than in 3 years in the unweeded spots (fig. F-1). The advantage of weeding was less but still substantial in the metamorphic area (table F-1).

The chances of success in direct-seedings in the Black Hills should be materially increased by advance site preparation that destroys or reduces existing vegetation.



1-year-old seedling grown free of competing vegetation

3-year-old seedling grown in competition with natural vegetation

Figure F-1. --Seedlings of ponderosa pines grown on soil derived from limestone.

Table F-1. --Average penetration of taproots and lateral roots of seedlings grown on weeded plots and in unweeded spots

Seedling source and age	Metamorphic area		Limestone area	
	Taproot	Laterals	Taproot	Laterals
	- - - - - Inches - - - - -			
Weeded plot[1]				
1 year old	13.6	6.6	13.3	4.6
Unweeded seed spots[2]				
1 year old	11.3	1.8	--	--
2 years old	14.2	4.4	10.5	1.7
3 years old	19.3	8.0	10.4	3.3

[1] 9 trees in each sample

[2] 6 trees in each sample

Ponderosa pines change form after thinning

Estimates of future growth of recently thinned young stands of ponderosa pine in the Black Hills may be erroneous if based on diameter growth at breast height soon after thinning.

The form of a tree stem is determined in part by bending stresses caused by wind. Densely grown trees tend to have little taper and relatively weak bases and root systems. Thinning exposes the trees to increased winds. The first reaction of the tree is to strengthen its basal section and increase the taper of the stem. Later, as the crowns close again, the trees will tend to reduce taper by increasing the proportion of wood that is laid down on the upper parts of the stem. The changes in bole form that accompany the response of trees to thinning might require new local volume tables every few years if volume growth is to be appraised accurately.

Thinning of two dense young stands of ponderosa pine in the Black Hills was followed by greatly increased diameter growth in the lower boles. The increased growth began the third year after thinning and continued 4 to 6 years in most trees of the 2 stands measured. Rings formed the third year after thinning were 1.7 to 13.7 times larger than those formed just prior to thinning. Diameter growth during the 4- to 6-year period, however, was no indication of growth over the 10- or 20-year period for which growth predictions are commonly made (fig. F-2).

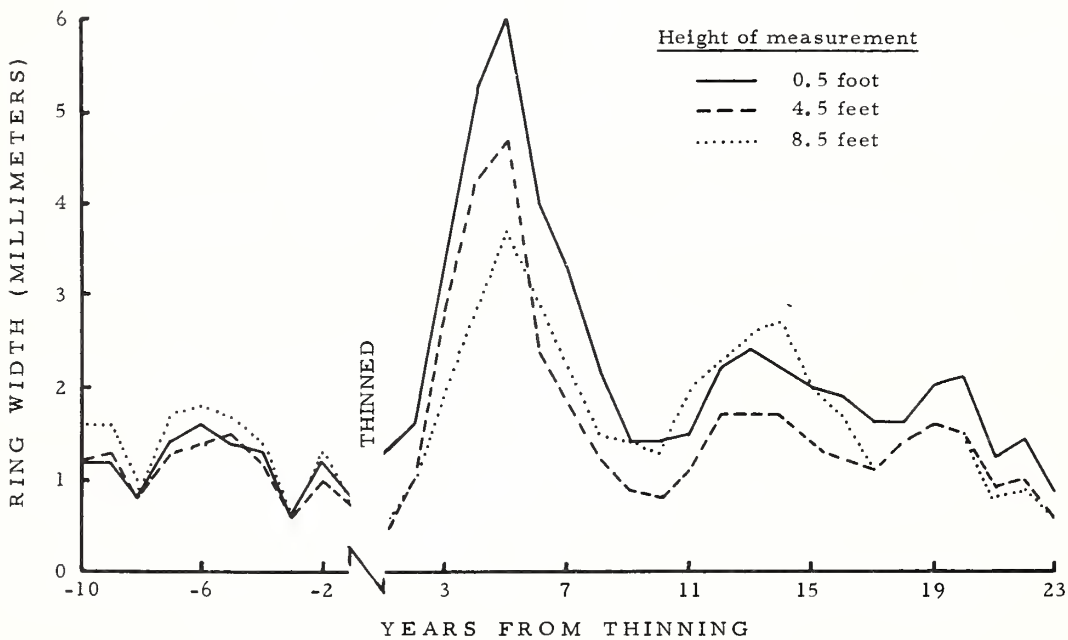


Figure F-2.--Ring widths in the lower bole of a tree 2.5 inches d.b.h. Growth increased greatly beginning the third year after thinning and declined from the sixth to ninth years.

Diameter growth increased throughout the tree boles for several years after thinning but was greatest at breast height and below. During the period of greatest growth, the rings were widest near the ground and were narrowest at about 70 percent of tree height. Before and after this period, the rings were narrowest at about 20 to 25 percent of tree height or near breast height. They were widest at about 75 percent of tree height or at the middle of the crown.

Both stands had been thinned heavily. In one, 19,632 trees per acre were thinned to 680 with diameters from 0.5 to 3.1 inches; in the other, 5,722 trees per acre were reduced to 378 with diameters from 1.2 to 4.9 inches.

Another point of interest is brought out by figure F-2. Adjustment of tree form was evident as early as the first year after thinning. For that year growth at breast height and above was about one-half less than the previous year; whereas, growth at 0.5 foot was about one-half more than the previous year. Apparently the trees produced little if any additional volume of wood in the first year after thinning but diverted most of it to strengthen the roots and basal section.

Disking for preparation of planting site reduces grass density

A farm-type tandem disk drawn three times over an area that was occupied by a dense cover of Arizona fescue and mountain muhly reduced but did not completely destroy the cover. Density measured by the basal-area intercept method was reduced from 16 percent to 4 percent (spring disking) and 2 percent (fall disking). Two years later the grass cover was still only 4 percent where disked in the spring and 6 percent where disked in the fall.

Windbreak-management research looks promising

The multi-row windbreaks planted by the Prairie States Forestry Project 20 to 25 years ago were designed to provide wind-lifting foliage from low-growing shrubs on the outside, to tall-growing trees in the middle. Conifers were commonly planted inside the shrub row to provide a row of long-lived trees that would function as well in winter as in summer.

As different tree species have responded differently to the climate and the many soils of the Plains, all species have not performed as expected in all places. Species such as the Russian-olive that were planted as shrubs have grown into trees. They no longer perform the function of shrubs, and they have overtopped and suppressed the valuable conifers in the adjacent rows (fig. F-3).

Seven weeks after cutting the row of Russian-olive to permit the adjacent eastern redcedar to develop, sprouts are already 2 to 3 feet high (fig. F-4). In a short time the dense sprout growth should perform efficiently the true function of a shrub row--to keep the wind from sweeping under the trees.

Removal of the outside "shrub" row is not always sufficient to permit the conifers to develop properly, especially if the conifer is ponderosa pine. Ponderosa pine grows poorly when crowded and is often overtopped on both sides (fig. F-5).

After removal of the inside row of deciduous trees, the ponderosa pine row is free to develop as a valuable screen against winter winds (fig. F-6).

Figure F-3. --Russian-olive, planted as a shrub, has grown to tree size. It overtops the adjacent row of eastern redcedar, which is exposed here by removal of the Russian-olive.

Figure F-4. --Seven weeks after cutting, Russian-olive sprouts from the stumps are reestablishing an effective shrub row.

Figure F-5. --Removal of a row of Russian-olive leaves a row of suppressed ponderosa pine still overtopped by green ash.

Figure F-6. --Removal of Russian-olive from the outside, and a row of green ash from the inside, frees a row of ponderosa pine so it can grow.

Some benefits and damages to fuels and trees from intentional burning of ponderosa pine timberland determined

An objective evaluation of several of the benefits and damages from intentional burning of ponderosa pine timberlands has been obtained. A tract of nearly 30,000 acres on the Fort Apache Indian Reservation, Arizona, was burned by experienced men under conditions of low fire danger in November and December 1956. The influence of the fire on fuels and trees was recorded at 6,666 sample points that were systematically distributed over the whole area. Some highlights follow:

1. Of the total area in the tract, 22 percent did not burn, 55 percent was burned by light surface fire, 17 percent by hot surface fire, and 6 percent by crown fire.

2. Both benefits and damages were small on the 77 percent of the area in the tract that either did not burn or burned by light surface fire. The important effects of the fire were confined to the 23 percent of the area that burned by hot surface or crown fire.

3. Fuel reduction was proportional to fire intensity by definition of the fire-intensity classes. On the area that did not burn, none of the fuel was consumed. In the area that burned by light surface fire, a small amount of fluffed-up litter on the surface was consumed, but little coarse fuel burned. In the area burned by hot surface fire practically all the litter and much of the coarse fuel on the ground was consumed, and in the area burned by crown fire practically all the surface fuel plus the fine fuel was consumed.

4. Three and one-half percent of the total number of potential understory crop trees, trees needed to utilize growing space, were released from growth-restraining competition, but 10.9 percent of the total number of potential crop trees were killed and 8.2 percent were damaged; 0.8 percent of the saw-log-sized overstory trees were killed and 6.9 percent damaged.

5. Benefits were directly proportional to fire intensity--more fuel was consumed and a larger proportion of potential crop trees in need of release were released at the higher intensities (fig. F-7).

6. But damages were also directly proportional to fire intensity. The more intense the fire, the more potential crop trees were damaged or killed (fig. F-8). An average of 5.5 potential crop trees were damaged or killed for each one released.

7. Under the burning conditions that prevailed, the fire in all except recently cut moderately stocked stands burned most intensely in open stands, less intensely in dense stands. In recently cut stands the relationship between fire intensity and stand density was less consistent. Throughout the burned area, however, there was a tendency for the fire to be less beneficial in terms of fuel reduction and needed release of potential crop trees in dense stands where the benefits were most needed.

8. Presence of slash intensified damages. Where there was slash a larger percentage of the area in dense understory stands crowned, more potential understory crop trees were killed, and more saw-log-sized trees were damaged.

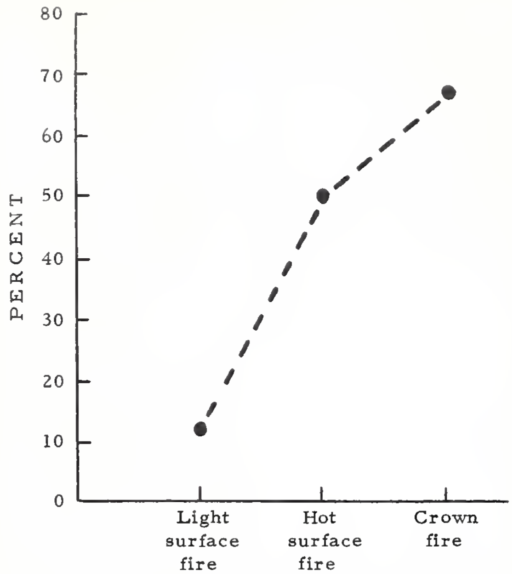


Figure F-7. --The percentage of potential crop trees in need of release that were released in areas burned by fire of different intensities.

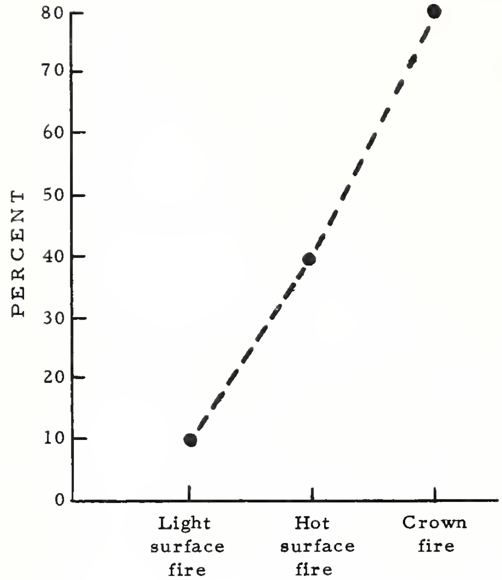


Figure F-8. --The percentage of potential crop trees damaged or killed by fire-intensity classes. (Basis includes both potential crop trees that needed, and did not need, release.)

Moisture content of living chaparral is important in behavior of fire

Samples of foliage and small twigs of shrub live oak were collected in the areas of a 30,000-acre wildfire and a 600-acre intentional fire that burned in chaparral at the same time within 80 miles of each other in north-central Arizona.

Moisture content of leaves measured only 5.6 percent and of small twigs only 29.4 percent in the wildfire area. This is abnormally low. In small islands of chaparral on moist sites that were bypassed by the wildfire, moisture averaged 67.7 percent in leaves and 58.6 percent in small twigs.

Chaparral burned poorly in the intentional burn. The fire did not run. It was necessary to light almost every clump of chaparral and even then a substantial layer of ground litter was needed to produce enough heat to consume the living fuel. There the moisture content of leaves was 94.2 percent and of twigs 69.4 percent.

The wildfire area received only a trace of precipitation during 3 months preceding the fire, according to measurements made on the area. The area intentionally burned apparently had more than 1 inch during the same time, according to measurements from the nearest weather station. Maximum temperatures on both areas during the fires were 100°F. or more.

FOREST INSECT RESEARCH

FOREST INSECT CONDITIONS IN ARIZONA AND NEW MEXICO

Spruce budworm outbreaks increase

Damage by the spruce budworm (Choristoneura fumiferana (Clem.)) increased in area from 323,840 acres in 1958 to 703,220 acres in 1959 (fig. I-1).

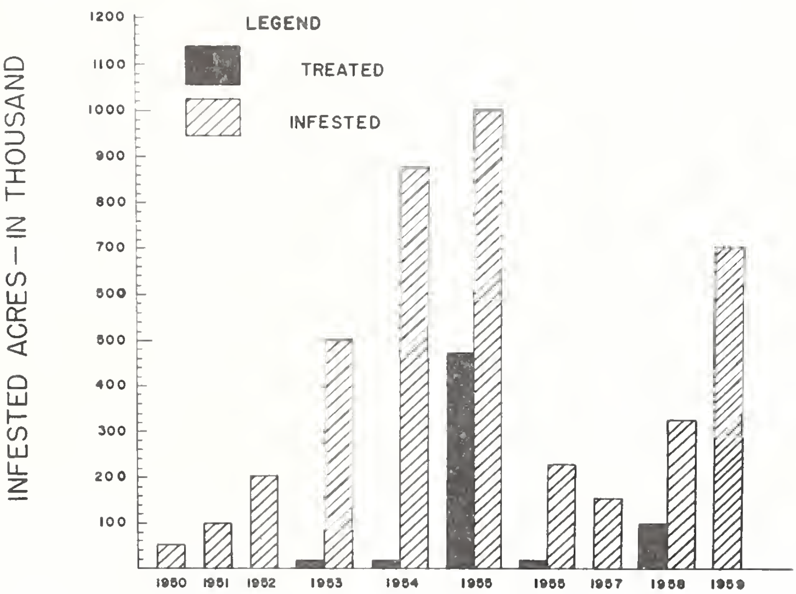


Figure I-1.--The area of spruce budworm damage increased gradually from 1950 to 1955 when nearly one-half million acres of mixed-conifer forest were sprayed with DDT. The budworm population then decreased and remained at a low level for 2 years except on the Kaibab National Forest and Grand Canyon National Park. That area was sprayed in 1958 with good results. Most of the 1958 and 1959 infestations are in northern New Mexico, some of which are in the areas treated in 1955.

The mixed conifers on the Carson and Santa Fe National Forests and adjacent private land where the outbreaks have been in progress for several years were hardest hit. A more recent outbreak on the Navajo Indian Reservation increased from 15,680 acres in 1958 to 83,300 acres in 1959. Acres of infestation and degree of defoliation in each of the three areas are shown below. Defoliation categories are as follows: Light, defoliation barely visible from the air; moderate, top one-fourth of tree defoliated; heavy, one-half of tree defoliated, top killing in progress; very heavy, three-fourths of tree defoliated, tree killing in progress.

Area	Degree of defoliation: Light	Moderate	Heavy	Very heavy	Total
	- - - - - - - - - -	- - - - -	(Acres)	- - - - - - - - - -	- -
Carson National Forest and adjacent private land	407,080	37,060	4,000	640	448,780
Santa Fe National Forest and adjacent private land	62,500	87,200	21,440	--	171,140
Navajo Indian Reservation	50,500	29,600	3,200	--	83,300
Total	520,080	153,860	28,640	640	703,220

Serious spruce budworm damage forecast for 1960

An evaluation of the abundance of insect parasites of the 1958-59 generation and the number of egg masses deposited by the moths in July for the 1959-60 generation indicates a continued upward trend of the spruce budworm in northern New Mexico. The density of the parasites of the larval and pupal stage is too low to curb the outbreak. Also, only 1.4 percent of the egg masses were parasitized. A fivefold increase in egg deposit in 1959 portends a bad budworm year for 1960. The average number of new egg masses per thousand square inches of foliage was 32 in 1959 and 6 in 1958. These average figures are based upon the examination of 1 branch from each of 5 trees in 18 plots. See figures I-2 to I-4 for methods of evaluating egg mass abundance.

Figure I-2. --

Two branches from opposite sides of a moderately defoliated Douglas-fir are cut from midcrown to sample the density of spruce budworm egg masses.

Figure I-3. --

The twigs on one-half of each two branches are cut and discarded, the right side of one branch and the left side of the other. Five such pairs from five trees constitute a plot.

Figure I-4. --The branch samples are taken to a central location where each needle is examined and each egg mass of the spruce budworm is recorded. The needles on approximately 20 branches can be examined per day by 4 technicians.

Douglas-fir tussock moth outbreaks controlled

Four widely separated outbreaks of the Douglas-fir tussock moth (Hemerocampa pseudotsugata McD.) in white fir in New Mexico and Arizona were aerially sprayed by the U. S. Forest Service. The 1 pound of DDT in fuel oil per acre applied in June 1959 gave satisfactory results. Areas and acreage treated were: Sandia Mountain, Cibola National Forest, 17,900 acres; Capitan Mountain, Lincoln National Forest, 1,800 acres; and Baker and Pinal Mountains, Tonto National Forest, 5,812 and 3,844 acres, respectively.

The explosive nature of the population of the insect was well demonstrated in the Sandia Mountain outbreak. Erupting from several undetected centers, most of them less than 5 acres in size, the infestation enlarged to 18,000 acres in 1958 (fig. I-5).

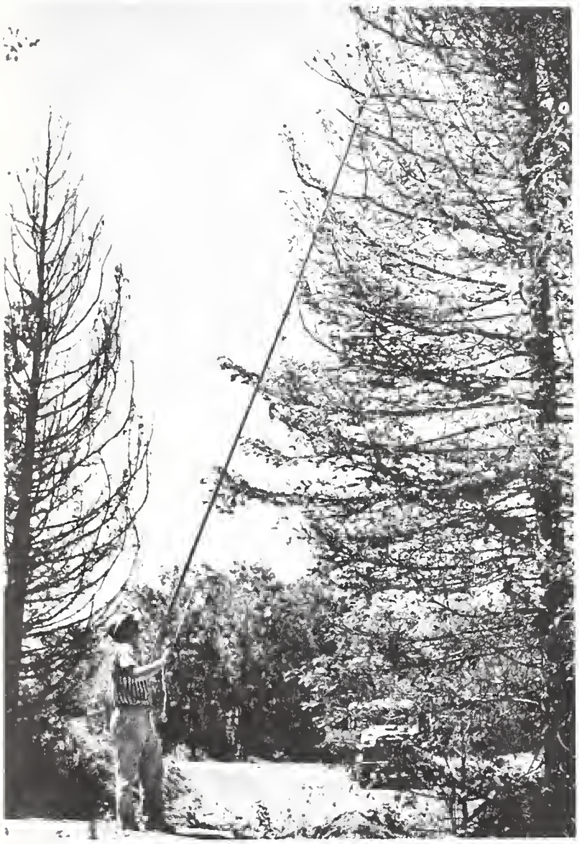


Figure I-5. -- Branches are collected from midcrown of partially defoliated white fir trees to evaluate the abundance of Douglas-fir tussock moth egg masses and the need for chemical control.

Engelmann spruce beetle outbreak discovered in northern New Mexico

A serious outbreak of the Engelmann spruce beetle (Dendroctonus engelmanni Hopk.) is present in a half-mile belt of spruce that abuts current and past logging operations on land owned by Chama Land and Cattle Company near Chama, New Mexico. The outbreak stemmed from populations that built up in the 1958-infested trees in cutover areas. Average beetle density in 25 sample trees was 77 adults per square foot. Woodpecker work is light in the area. Little or no entomophagous parasitism or predation was noted. Continued increase in the infestation is predicted for 1960 unless controlled.

Pine bark beetle damage declines

Mortality of ponderosa pine throughout Arizona and New Mexico caused by the complex of *Dendroctonus* and *Ips* beetles continued to decline in 1959. *Ips* beetles enter and kill the top section of the stems. *Dendroctonus* beetles, usually *D. barberi* Hopk., fill in and kill the lower sections. Other bark beetles involved in this pine mortality were *D. convexifrons* Hopk., *D. parallelocollis* Chap., and *I. ponderosae* Sw. Losses were heaviest within the Lincoln National Forest and San Carlos Indian Reservation.

Arizona five-spined engraver threatens recreation areas

An infestation of Arizona five-spined engraver (*Ips lecontei* Sw.) is killing sapling and sawtimber-sized trees in ponderosa pine stands in recreation sites near Prescott, Arizona. Single trees and groups of 60 or more are being killed. The brood are numerous.

Fir engraver damage increases

The fir engraver (*Scolytus ventralis* Lec.) outbreak discovered last year in white fir on Lincoln National Forest, east of Ruidoso, New Mexico, has enlarged to 25,000 acres and now includes stands on the adjacent Mescalero Indian Reservation. Volume loss is extremely high because of the predominance of large-diameter fir trees in the stands.

The beetle continues to deplete the white fir stands on Sandia Mountain east of Albuquerque, New Mexico. Increased activity by the insect was also recorded on the Prescott National Forest in 1959.

Douglas-fir beetle damage continues

Localized outbreaks of the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.) are continuing throughout the Douglas-fir stands of the region. The amount of damage declined in 1958 but showed an increase in 1959. Losses are heaviest on the Santa Fe and Coronado National Forests. Much of the area is inaccessible.

New Mexico fir looper infestation found

In the fall of 1958 an outbreak of the New Mexico fir looper (*Galenera consimilis* Hein.) in association with Douglas-fir tussock moth was found on 1,500 acres in the Capitan Mountains, Lincoln National Forest in New Mexico. This is the first report of any activity by the looper since 1952, when an infestation was controlled in the Sacramento Mountains on the same forest.

A disease organism is believed to have been responsible for the death of many pupae. Less than 15 percent of the pupae were alive when examined in the spring of 1959. The infestation was treated in conjunction with the tussock moth control project. This precluded a measurement of the final effectiveness of the disease.

Black Hills beetle extends range

The Black Hills beetle (Dendroctonus ponderosae Hopk.) was found for the first time in the San Mateo Mountains of the Cibola National Forest. The host was limber pine. This is the most southerly record for the beetle.

Forest insect conditions in southwest national parks and monuments

Insect activity in the national parks and monuments of the southwest was relatively light in 1959. With the exception of the Douglas-fir beetle, no other bark beetles or defoliators were epidemic. As usual, defoliators of stream-bottom hardwoods continued to be troublesome but not serious.

The Douglas-fir beetle continues to be epidemic on the north rim of Grand Canyon. The infestation extends from the steep canyon slopes to the plateau. This condition has existed for several years, with the beetle-infested trees scattered widely, in much the same way as Douglas-fir is scattered. There is no practical way to combat this epidemic.

Ponderosa pine on the north rim of Grand Canyon continues to sustain considerable mortality from combined attacks of Ips and Dendroctonus beetles. This high, annual, endemic loss is maintained in part by the high incidence of lightning strikes, which provide suitable breeding material for the bark beetles.

Ips confusus (Lec.) has also built up in pinyon pine killed by the fungus Leptographium sp. at Mesa Verde National Park and is killing small groups around the fungus-killed trees.

No damage by the spruce budworm was found in 1959 on the north rim of Grand Canyon following treatment with DDT in 1958.

A definite downward trend in Great Basin tent caterpillar (Malacosoma fragile (Stretch)) damage was evident in 1959. Chemical control was applied at Grand Canyon National Park. Disease played an important part in reducing populations at Mesa Verde National Park and Bandelier National Monument.

The fall webworm (Hyphantria cunea Drury) was epidemic at Carlsbad Cavern National Park and Bandelier, Chaco Canyon, and Aztec Ruins National Monuments in 1959.

The walnut caterpillar (Datana sp.) infestation at Carlsbad Caverns National Park declined noticeably in 1959 in both sprayed and unsprayed areas. Early in the season when the caterpillar was in the egg stage, severe infestations of an aphid developed on the walnut. One quart of 50-percent emulsifiable Malathion was used in each 100 gallons of water. This spray gave satisfactory control of both the aphids and the walnut caterpillars.

A sycamore lacebug at Montezuma Castle National Monument was generally light during 1959 but heavy enough on some trees to warrant control. This insect is likely to remain a perennial problem because of reinfestation from surrounding areas.

FOREST INSECT CONDITIONS IN
COLORADO, WYOMING, AND SOUTH DAKOTA

Spruce budworm epidemic in Colorado

The spruce budworm damage on several areas in southern Colorado showed a critical increase in 1959 (fig. I-6).

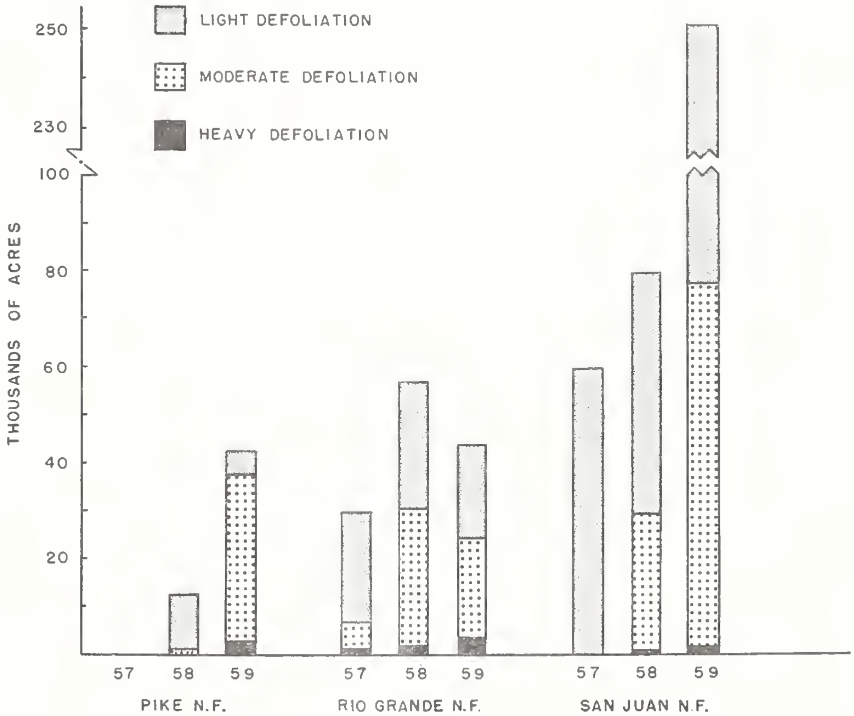


Figure I-6. --Area and intensity of spruce budworm infestations on 3 national forests in Colorado during the past 3 years.

The areas and degree of defoliation are as follows:

Area	Degree of defoliation				
	Light	Moderate	Heavy	Very heavy	Total
	- - - - - - - - - - - -	(Acres)	- - - - - - - - - - - -		
Pike National Forest	4,940	35,120	2,250	0	42,310
Routt National Forest	0	440	0	0	440
Rio Grande National Forest	19,550	20,810	3,220	0	43,580
San Juan National Forest	174,180	75,520	1,790	0	251,490
Tierra Amarilla Grant	10,190	560	0	0	10,750
Uncompahgre National Forest	0	1,030	0	0	1,030
Total	208,860	133,480	7,260	0	349,600

The Douglas-fir within the infestation on the Pike National Forest received heavy defoliation on 2,250 acres and moderate defoliation on 35,120 acres. The infestation was discovered during the 1958 aerial survey, when the degree of defoliation was light. Because of the newness of the infestation, tree mortality has not resulted. Some top killing can be expected in 1960.

The infestation on the Del Norte District of the Rio Grande National Forest has been present for 16 years. Since 1954, the intensity has increased. Many trees in both the overstory and understory have been killed. Other trees are sparsely foliated and critically weakened from the effects of budworm feeding during the past 6 years. Natural factors are not controlling this outbreak.

The outbreaks on the San Juan National Forest are scattered throughout the Douglas-fir and white fir types. If the infestations continue, a much greater area will be enveloped.

Heavy egg mass deposit portends heavy spruce budworm damage in Colorado in 1960

Each of 28 sample plots showed a greater number of egg masses deposited in 1959 than in 1958. Figures I-2, I-3, and I-4 (pages 40-41) illustrate the sampling methods. Less than 5 percent of the masses have been destroyed by parasites. Also, insect parasitism of the larval and pupal stages is low. The outbreaks in southern Colorado, like those in northern New Mexico, are expected to become more severe in 1960 unless unforeseen natural mortality factors become highly effective or the outbreaks are sprayed with DDT.

Egg mass abundance on three national forests was as follows:

	National Forests		
	Pike	Rio Grande	San Juan
Number of plots	6	11	11
Egg masses per M square inch of foliage:			
September 1959	83.9	18.8	21.6
Preceding 1959	21.8	6.4	8.3
Ratio of 1959 to preceding	3.8:1	2.9:1	2.6:1

Engelmann spruce beetle epidemic in several areas in Colorado

The Engelmann spruce beetle continues to be a serious problem in Colorado. All except four of the infestations are within or adjacent to timber sales. The excepted areas were discovered in standing trees in the Orphan Butte area of the San Juan National Forest northwest of Durango, Colorado. Approximately 1,150 trees are infested. On the Uncompahgre National Forest approximately 20,000 spruce are infested in one uncut block adjacent to sale areas.

Epidemic beetle populations can develop in cull logs, such as were found in the 45 sale areas examined on national forests. The average number of living spruce beetles per square foot was 32, or 2.5 times the number of parent beetles. National forests involved in the outbreaks are Uncompahgre, Gunnison, Rio Grande, Routt, and San Juan.

Spruce beetles in cull logs present a serious problem

The build-up of large populations of spruce beetles in cull logs has become common. The increase in number, size, and length of sales and the high percentage

of cull is responsible. The beetles infest the undersides and shaded parts of the logs. Natural-control factors are ineffective. Snow protects the overwintering broods from low temperatures and predation by woodpeckers. As logging operations continue, the beetle population build-up often goes unnoticed because beetles emerging from cull logs reinfest green cull. One to two years after a sale is terminated, the emerging beetles infest standing trees in adjacent uncut blocks. The build-up and spread of the population can be prevented by trap-tree programs, salvage, and disposal of cull after each beetle flight. Whatever the practice, it demands close supervision.

The Forest Service, on a limited scale in the last 2 years, has been trying to combat spruce beetles through tree-length logging. The felled trees are moved to a central point where the tops and cull logs are piled. After each beetle flight and when the cull logs are infested, the piles are burned. The slash mixed with the cull logs aids combustion of the piles. The small number of beetles produced in the slash is not a problem. A modification of this method is also used. It involves windrowing slash and cull by bulldozer then burning the windrows after the beetle flight. Both systems are effective and appear to eliminate spruce beetle build-up in cull logs.

Trap trees felled to control Engelmann spruce beetle

Large numbers of hibernating beetles are present in most of the cull logs in 45 timber-sale areas examined. The beetles will emerge and fly as soon as the snow melts in June 1960. Chemical control of these beetles is not physically possible because of the inaccessibility of the areas during the months before the hibernating adults fly. To check the spread of the infestation, the U. S. Forest Service cut 5,000 spruce trees to trap the beetles. These felled trees are covered by snow throughout the winter and are attractive to spruce beetles at the time of flight in June and July. The trees were felled in groups of 50 or more adjacent to logging areas. These traps will be salvaged or chemically treated after the 1960 beetle flight.

Engelmann spruce beetle continues endemic in spruce blowdown on White River National Forest

In September 1957 a storm hit the White River National Forest and broke off and uprooted blocks of Engelmann spruce. Two years and two beetle flights later, 47 of those trees were sampled and found to be only lightly infested with the Engelmann spruce beetle. An average of only 0.2 entrance hole and 5.7 larvae and adults per square foot were found. A similar sample in 1958 had revealed even less activity--0.04 entrance hole and 2.29 eggs and larvae per square foot. The inner bark on the undersides of the trees is still fresh and will be attractive to beetles that fly in 1960. An outbreak from this blowdown is still possible.

Helicopter used for Engelmann spruce beetle detection surveys

A three-place helicopter (fig. I-7) was used to cover part of the inaccessible Engelmann spruce type on the Rio Grande, San Juan, Uncompahgre, Gunnison, White River, Routt, and Arapaho National Forests during August. Approximately 3 million acres of spruce were covered in 31.6 hours. Sixteen Engelmann spruce beetle infestations were detected and recorded on aerial work maps. Four had not been discovered and reported. Twelve were adjacent to logged areas and might readily have been spotted from the ground and reported. The four could have gone undetected for a long time.

Figure I-7.--Frequent ground inspections of Engelmann spruce beetle infestations are possible by landing the helicopter in open parks such as this one in the West Fork of the Cimarron River, Uncompahgre National Forest.

The general performance of the helicopter for this survey exceeded all expectations. Landings and takeoffs were made above 12,000 feet. The aircraft responded well to the pilot's demands; rate of climb was excellent; it handled well in steep narrow drainages; it flew up steep drainages, climbed over the ridge, and descended into the drainage on the other side; and because of its maneuverability it was able to fly the contour pattern of coverage perfectly. Slow speed often at treetop level and unobstructed forward, lateral, and downward visibility contribute greatly to the success of the observer in locating incipient outbreaks.

Black Hills beetle infestations continue to increase

Black Hills beetle infestations total 62,550 acres in the ponderosa pine type of Colorado and central Wyoming. The greatest increases in infestations are along the Front Range of Colorado. About 9,330 ponderosa pines were treated by land managers in 1959 at a cost of more than $40,000. More than 7,000 of those trees were on the Black Hills National Forest in South Dakota. Woodpeckers have aided only slightly in overall control.

Outbreaks of Douglas-fir beetle increase in Wyoming and decrease in Colorado

Douglas-fir beetle infestations total 7,450 acres in Colorado and Wyoming. While acreage of infestation decreased on the Pike, Rio Grande, Roosevelt, San Isabel, San Juan, and Medicine Bow National Forests, it has increased on the Shoshone National Forest and in the South Bighorn Mountains in Wyoming where brood densities are high. A pilot project to evaluate the effectiveness of direct control with ethylene dibromide has been proposed on the Shoshone National Forest.

First experience in measuring the brood density for forecasting infestation trend indicates no significant difference in the density at breast height and at 10 to 12 feet.

Mountain pine beetle infestations on Shoshone National Forest

Mountain pine beetle (Dendroctonus monticolae Hopk.) infestations on the Shoshone National Forest in Wyoming decreased in lodgepole pine stands and increased in limber pine stands. Woodpecker activity was responsible for the decrease in lodgepole pine on the Wind River District. Approximately 1,000 infested limber and lodgepole pines on the Wapiti District were treated with ethylene dibromide in 1959.

Outbreak of pandora moth discovered

An outbreak of the pandora moth (Coloradia pandora Blake) in stands of lodgepole pine near the Wyoming-Colorado boundary on the Medicine Bow and Routt National Forests was discovered in July 1959. Immediately after discovery the infestation was delineated by aerial methods and found to be 8,420 acres in size. Defoliation is light to heavy. The most recent outbreak in the region occurred in 1937-39 on the Arapaho National Forest in Colorado.

Overwintering pupae in the soil are extremely abundant. The moths will fly and lay their eggs in June and July 1960. The feeding in 1960 will cause very little foliage loss. Most of the larval growth and defoliation will take place in 1961. The insect has a 2-year life cycle.

Great Basin tent caterpillar outbreaks subside

Great Basin tent caterpillar infestations in aspen stands in southern Colorado decreased because of biological control factors. As a result of repeated defoliation during the 10-year epidemic, tree mortality was becoming heavy.

RESEARCH

Life history of Arizona five-spined engraver

The overwintering generation of the Arizona five-spined engraver flew and infested ponderosa pine in late April. The new adults from this first generation emerged and infested green trees in early July. The adults of the second generation emerged and infested new trees in the middle of August. The progeny of this generation reached the adult stage in the fall and will hibernate until April 1960. Thus there were three generations in the study area near Prescott, Arizona. The life cycle was determined by the use of cages (fig. I-8). Many parent adults of each generation re-emerge and infest new trees. Also the variability in rate of development of the broods results in trees being infested at all times during the summer. As a result, many stages of the insect may be found at all times.

Life history and habits of Douglas-fir tussock moth

The life cycle of the Douglas-fir tussock moth in New Mexico and Arizona was found to be similar to that in the northern Rocky Mountains. Egg hatch started

May 29 and ended June 24. The larvae have five instars. The rate of growth of the larvae was variable. Pupation was first noted on June 29. A few larvae pupated as late as the last week of August. Average length of the pupal stage was 26 days. The moths emerged from late July to early September. The females are wingless and lay their eggs upon the cocoon.

The polyhedral virus disease that decimates infestations in the northwest was experimentally effective in killing the caterpillars in the laboratory and also in the field. Also, several larvae naturally infected with this disease were found in the infestation on Sandia Mountain.

White fir is the preferred host in the Southwest, occasionally feeding on Douglas-fir. The early instars feed only on the new needles. After all white fir and Douglas-fir foliage is consumed, the larvae may defoliate ponderosa pine.

Exploratory control tests successful against pinyon needle scale

New information on the life history of the pinyon needle scale (*Matsucoccus acalyptus* Herbert) should lead to the development of successful control measures. Previously, insecticides have been applied during the crawler stage without success. It was discovered that the adult scales lay their eggs during late April and early May in masses at the base of the trees and in the adjacent duff. A lesser number are laid in the crotches of large branches, underside of branches with rough bark, and in bark fissures. The eggs hatch about June 1. Five treatments were tested while the scale was in the egg stage: (1) 4-percent Dimethoate at 2 ml. per inch of circumference; (2) 4-percent Dimethoate at 4 ml. per inch of circumference; (3) Dri-Die dust; (4) diesel oil; and (5) scraping eggs away from the tree. Treatments 1 and 2 in which the Dimethoate in water was poured around the base of the trees gave satisfactory control. Apparently the Dimethoate killed the eggs directly and also enough was taken up by the trees to kill the crawlers. Treatment 3 gave poor results. Treatment 4 gave good results but the oil may injure the trees. Treatment 5 was successful but the method is impractical except when only a few trees are involved. Further field testing with Dimethoate and ovicides is needed to refine the dosages and methods of treatment.

Forecasting trends of Black Hills beetle infestations

Average density of brood of the Black Hills beetle beneath 50 bark samples of ponderosa pine, 6 by 6 inches, removed from the boles of 25 trees at 4 to 7 feet aboveground during early July can be used as indicators of the infestation trend. Trend is expressed in terms of the number of trees that become infested by the emerging population: (1) Increasing--the emerging beetles kill more trees than their parents; (2) static--they kill about the same number; and (3) decreasing--they kill fewer trees.

To determine this relationship, brood densities were measured in September soon after most of the eggs had hatched, again in April during the large larval stage, and finally, in early July just before the new adults are ready to fly and infest new trees. The number of newly infested trees was determined following the beetle flight. The September measurements showed no relationship; the April measurements began to show some relationship; and the July measurements, a close relationship. The average density per square foot of bark in April and early July in 7 decreasing, 4 static, and 5 increasing infestations was as follows:

Figure I-8.--

Soon after the trees are infested with the Arizona five-spined engraver, wire-screen cages are attached to collect the emerging progeny and learn the length of the generation. Some information about the associated insects is also obtained.

	Decreasing		Static		Increasing	
	April	July	April	July	April	July
	30	9	114	25	137	72
	38	5	106	26	93	36
	64	1	59	27	89	38
	35	4	62	23	129	64
	36	6			159	74
	89	2				
	90	14				
Average	55	6	85	25	121	57

Sequential sampling of Black Hills beetle broods

A procedure has been developed for estimating Black Hills beetle densities that permits a flexible number of samples instead of the fixed number required in conventional methods. This procedure, called sequential sampling, requires that sample units be taken until the cumulative counts of beetles meet the standards of

one of three infestation trend categories: Decreasing, static, or increasing. In evaluation of infestations, the predictions are based upon survival of beetles in early July before flight. The following tabulation is for use in the field in July:

Number of samples examined	Cumulative number of beetles		
	Decreasing	Static	Increasing
20	7		297
22	16		314
24	25		30
26	34		47
28	43		64
30	52		81
32	61		98
34	70		415
36	79		32
38	88		49
40	96		66
42	105		83
44	14		500
46	23		17
48	32		34

Number of samples examined	Cumulative number of beetles		
	Decreasing	Static	Increasing
50	41		51
52	50		68
54	59	324 to 330	85
56	68	33 to 47	602
58	77	42 to 64	18
60	86	50 to 81	35
62	95	59 to 98	52
64	204	68 to 415	69
66	13	77 to 32	86
68	21	86 to 49	703
70	30	95 to 66	20
72	39	404 to 83	37
74	48	13 to 99	54
76	57	22 to 516	71
78	66	31 to 33	87
80	75	40 to 50	804

The application of the system and the table is quite simple. Two 6- by 6-inch patches of bark are removed from each tree and the brood beneath is counted. The brood count is added to the total count from previous samples. After the brood from 10 trees (20 samples) have been sampled and tallied the table is checked. If 7 beetles or less have been tallied the infestation will decrease. If the total is more than 297 the infestation will increase. If it is between 7 and 297 sampling must continue. The table is checked after each tree has been sampled. Three decisions may be made when 54 or more sample counts have been cumulated. For example, at 54 samples if the total is less than 59 the infestation will decrease; if between 324 and 330 it will remain static, and if more than 585 it will increase. If no decision can be made after counts are cumulated for 80 samples, the infestation may be classified in the higher of the two possible categories.

Tests of systemic insecticides continues

Seven systemic insecticides for control of the Engelmann spruce beetle have been evaluated. The chemicals have been applied by trunk implants, root collar drench, and as granules around the root collars of infested Engelmann spruce. Results with some of these chemicals show enough promise to warrant more extensive testing.

Tests of systemic insecticides on American elm infested with the European elm scale (Gossyparia spuria (Mod.)) were also continued. Satisfactory conduction and mortality of the scale has not yet been attained when the chemicals are applied in a water drench or granular form around the root collar of the elm. Best experimental results have been attained with trunk implants, but the method is not yet a practical control method.

FOREST DISEASE RESEARCH

DWARFMISTLETOES

Dwarfmistletoe reduces yields in lodgepole pine

Effects of dwarfmistletoe on tree size and volume were studied in an 84-year-old stand of lodgepole pine on the Roosevelt National Forest, Colorado. The heavily infected part of the stand had been subject to dwarfmistletoe throughout its life; other parts of the stand were free of dwarfmistletoe. One-half by one-half chain (1/40-acre) plots were established in each part of the stand. The centers of the two plots were 82 feet apart. Topography was uniform. A comparison of the two areas is given below:

	Unit of measure	Degree of dwarfmistletoe: Heavy	Degree of dwarfmistletoe: None
Heights:			
Dominants and codominants	Ft.	14	36
All living trees	Ft.	10	32
Diameters:			
Dominants and codominants	In.	2.1	5.2
All living trees	In.	1.2	4.2
Basal area per acre:			
Living	Sq. ft.	58.4	192.9
Dead	Sq. ft.	12.8	6.0
Dead as percent of total	Pct.	18.0	3.0
Volume 1/ per acre:			
Total (trees 2.6 in. d.b.h. or larger)	Cu. ft.	100.0	3,304.0
Merchantable (trees larger than 4.6 in. d.b.h., 4.0 in. top, 1 ft. stump)	Cu. ft.	0	1,850.4

The dominants and codominants in the uninfected plot were about 2-1/2 times taller and larger in diameter than in the heavily infected parts. The most striking contrast was in merchantable cubic foot volume: None in the heavily infected plot; 1,850.4 cubic feet per acre in the uninfected plot. Several more such areas will be examined to provide information on the effects of dwarfmistletoe in stands of different ages and sites and in those that have been infected for various lengths of time.

1/ Hornibrook, E. M. Cubic-foot volume table for lodgepole pine. U. S. Forest Serv. Rocky Mountain Forest and Range Expt. Sta. Res. Note 4, 3 pp., 1948. [Processed.]

Observation plots help determine timing and extent of recleaning operations in dwarfmistletoe-control areas

In 1954, 3,033 ponderosa pines were treated in a dwarfmistletoe-control project on Bright Angel Point in Grand Canyon National Park. Only 57 percent of the treated trees could be pruned because of the intensity of the infection in several centers. Subsequent observations on a series of plots in these centers indicated that latent infections had developed rapidly, and that a recleaning operation should be scheduled for 1958. From the plots it appeared that all but 14 percent of the trees requiring treatment could be pruned. It was apparent, however, that an even smaller proportion would have to be destroyed if the infectiveness of each tree was to be properly assessed. In the 1958 recleaning, 523 trees with dwarfmistletoes were treated, and only 7 percent were felled or poisoned. This agreed closely with the treatment on the observation plots, where 6 percent were destroyed. As of June 1959, the plots had 26 infected trees, with 31 individual infections, as compared with 87 trees and 279 infections before recleaning. Included with the 26 trees were 8 trees that must have had latent or very small infections in 1958. A final cleanup of dwarfmistletoe was made in June 1959 to reduce residual infections revealed in the post-control check.

Between 1952 and 1955, a program of dwarfmistletoe control was carried out in submerchantable-sized classes of ponderosa pine on about 12,000 acres of the Whitetail logging unit in the Mescalero Apache Reservation of New Mexico. Previously, all infected merchantable-sized trees had been removed in a harvest cutting or in a subsequent salvage operation. To determine the optimum timing for the first recleaning of the control area, a series of observation plots was established in 1955 and 1956. The plots were purposely located in stands where dwarfmistletoe infection had been severe before control, and they were distributed in areas covered by control in 1953, 1954, and 1955. Annual examinations of the plots up to May 1959 have been summarized and indicate that recleaning should begin in the 1953 control area during fiscal year 1960. This is based on the fact that infection for all stems has leveled off (fig. D-1); the continued increase in pole infection is explained by the addition of infected stems from the sapling class, where a corresponding decrease occurred in dwarfmistletoe incidence.

An appraisal survey of the entire control unit is being made to provide the U. S. Bureau of Indian Affairs with information needed for planning and conducting the recleaning operation. A total of 57 temporary random 1/10-acre plots has been located and checked in the 1953-control area. Although 13 short of the number required to give a 0.1-percent sample of this area, the results suggest that direct control was needed originally on only 47 percent of the gross area included in the 1953 operation. Infection was moderate to heavy on only 20 percent of the area. Twenty-one percent of the plots fell in stands that had been damaged by a severe hailstorm on July 5, 1958, and about 14 percent were in moderate to heavy hail damage areas where both the host and the parasite have been virtually eliminated. Hence, recleaning will be unnecessary.

New items on chemical and biological control

Examinations of the 1958 spray tests on lodgepole pine dwarfmistletoe (*Arceuthobium americanum*) indicate that Acti-dione and its derivatives and maleic hydrazide are ineffective. Acti-dione did not kill the root system of the parasite and maleic hydrazide was more toxic to the host than to the mistletoe.

In 1959 the following sprays were tested on *A. americanum*: Solan, Karsil, Dacryl, No. 5996 (Niagara Chemical Division) and TINSAN (Stecker Chemicals, Inc.).

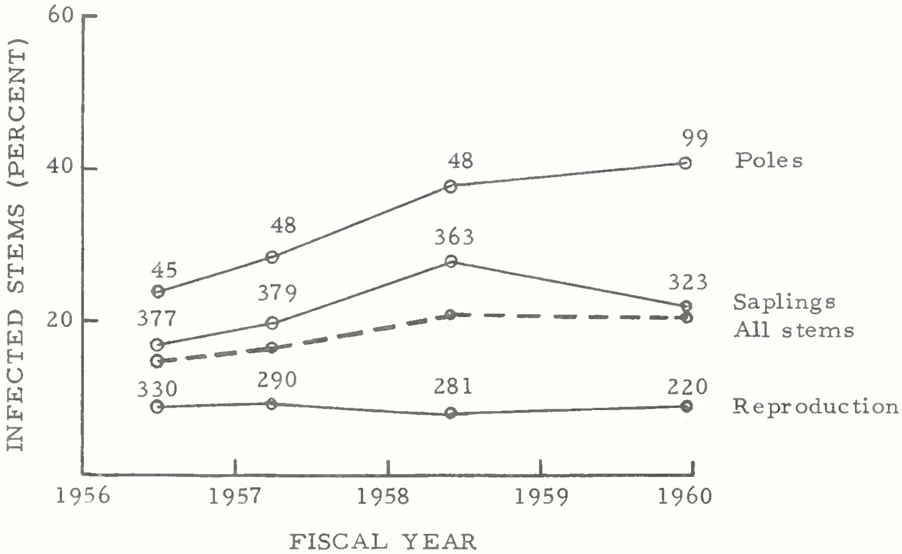


Figure D-1. --Trend of dwarfmistletoe development in stands that were severely infected prior to direct control in 1953. Percentage of all stems infected is based on the total number of poles, saplings, and reproduction plus a few merchantable-sized trees. Numbers shown on figure (45, 377, 330, etc.) indicate total number of trees at each date. Whitetail Control Unit, Mescalero Apache Reservation. Basis: twenty-six 1/10-acre plots.

There was no effect on either the host or parasite after 3 months. Further tests with higher concentrations of these chemicals are planned.

The fungus that causes resin disease has not yet been identified, although its pathogenicity has been confirmed by inoculations. The disease apparently occurs throughout the range of lodgepole pine dwarfmistletoe in the central Rockies. It has been found from the Shoshone and Bighorn National Forests in northern Wyoming to the Gunnison and Pike National Forests in central Colorado. However, it appears to be abundant enough to seriously affect the dwarfmistletoe only in certain parts of the Roosevelt National Forest in northern Colorado. Studies on the taxonomy, life history, and the potential importance of resin disease as a biological control agent are continuing.

Ponderosa pine tissues invaded by dwarfmistletoe were occasionally found to be necrotic. A portion of the host phloem was dark brown, with complete breakdown of the cellular structure. This condition extended slightly in the xylem in half of the six cases observed. There were no external manifestations of the necrosis. A Fusarium sp. has been isolated from the necrotic areas, but its role in the disease has not yet been determined.

Exploratory study of dwarfmistletoe host resistance started

A systematic search revealed 10 trees that exhibited phenotypical resistance to ponderosa pine dwarfmistletoe. These trees were located on the Cibola, Lincoln, and Coconino National Forests. Two of the trees were found during the period of dwarfmistletoe seed discharge and were artificially inoculated with seed obtained from plants growing nearby. Bark patch grafts of dwarfmistletoe-infected tissue were made this fall on each of the 10 trees as a part of the resistance tests to be applied to phenotypically resistant trees.

Two to three years required for dwarf-mistletoe to reach host cambium

Dissection of 41 artificial infections of known age on ponderosa pine revealed that in two-thirds of the cases a minimum of 2 years was required for sinkers of *Arceuthobium vaginatum* to reach the host cambium; in approximately one-third of the cases, 3 years were apparently required. Radial sinker penetration apparently was not influenced by branch age-at-infection within the range of the bulk of the sample (85 percent were on current, 1-year-old, or 2-year-old growth).

Flowering periods of dwarfmistletoe studied

The 1959 flowering periods in one locality in the Roosevelt National Forest, northern Colorado, were as follows: Approximately April 20 to May 20 for lodgepole pine dwarfmistletoe (*A. americanum*), and May 20 to June 20 for ponderosa pine dwarfmistletoe (*A. vaginatum* f. *cryptopodum*).

STEM CANKERS
(including rusts)

Sooty-bark canker damaging New Mexico aspen

Sooty-bark canker of aspen caused by *Cenangium singulare* was found for the first time in New Mexico in an overmature stand of aspen in the Chuska Mountains, Navajo Indian Reservation. The canker was common in this stand and in some areas seemed to be the primary cause of high mortality. Later in the season the same organism was found to be associated with excessive mortality on the Santa Fe National Forest.

General observations in New Mexico aspen revealed a profusion of the perfect stages of *Valsa sordida*, commonly accepted as the perfect stage of *Cytospora chrysosperma* and *Valsa translucens*.

V. translucens was collected on aspen in New Mexico for the first time in 1958. There are no previous reports of the perfect stage of *V. sordida* in the southwestern region on this host. The abundance of the perfect stages would seem to suggest ideal conditions for the development of canker fungi in 1959. However, hypoxylon canker was not observed in the several diseased stands that were examined.

New Engelmann spruce canker in Colorado

A resinous canker caused by *Cytospora kunzei* was found for the first time in Engelmann spruce in one area of the Pike National Forest. A few trees were killed by the disease, which appeared to be a secondary development, probably associated with hail injury. The causal fungus is the same species that causes the pitch canker or Sedalia canker of Douglas-fir in the lower parts of the Front Range of Colorado, although there may be varietal differences.

Western gall rust may go directly from pine to pine

The western gall rust (*Peridermium harknessii*) has long been presumed to require an alternate host to complete its life cycle. In 1957, aeciospores were introduced into wounds on 40 lodgepole pines. By 1959, 11 of these had formed

rust galls at the inoculation points, while the 32 controls, which were wounded but not inoculated, remained free of rust. The same inoculum gave rise to little or no infection on the supposed alternate hosts, scarlet paintbrush (Castilleja miniata) and yellow owlclover (Orthocarpus luteus). The few sporadic infections could easily have been contaminations from other species of pine rust in the forest. These results indicate that western gall rust may be transmitted primarily from pine to pine. Further studies of the role that alternate hosts may play, if any, will be made, including tests under greenhouse conditions where contamination can be excluded.

Additional impetus for this study arises from observation of extensive gall-rust infestation in Black Hills ponderosa pine. (Previously only lodgepole pine was known to be heavily damaged by this pathogen in the central Rocky Mountain region.) A limited survey indicated that trunk cankers were present on about 7 percent of the ponderosa pines in sample counts near Roubaix, South Dakota. In some open stands, 30 percent of the trunks are cankered, and nearly all of the trees in such stands bear numerous branch galls.

Limb rust range extended

Limb rust (Peridermium filamentosum) was also found to be common in some parts of the Black Hills; previously it was known only as far north as Colorado. Although this rust is reported to attack mainly older trees, it is common in 10- to 12-year-old ponderosa pine near Lead, South Dakota. Branch killing, but no tree mortality caused by this pathogen, is obvious in the area surveyed.

FOLIAGE DISEASES

Needle cast continued to threaten second-growth ponderosa pine in Arizona and New Mexico

Needle cast of ponderosa pine was more widespread in the southwestern region during 1959 than in 1958. It persisted in two areas on the Coconino and Prescott National Forests, where a biological evaluation of the disease was started in 1958.

For the first time since 1956, needle discoloration was marked in stands of the so-called Stoneman Lake area of the Coconino National Forest, and in much of the understory extending southward to the Mogollon Rim. Detection reports indicated other less extensive needle cast areas on the Prescott National Forest as well as the Coconino. In New Mexico, the disease was found on a large area in the Frisco District of the Gila National Forest, where discoloration of unknown cause had been noted by the aerial forest insect survey in 1957. Needle cast was also common on the Jemez District of the Santa Fe National Forest, and throughout the Mescalero Apache Indian Reservation. In the latter, the disease had been reported in 1957.

Preliminary results of 2 years' observations on 1/10-acre plots in the persistent centers on the Prescott and Coconino National Forests are summarized in the following tabulation. They indicate that the incidence of needle cast was about the same in 1958 and 1959. However, the proportion of trees with 1-year-old needles affected indicates that disease severity may have declined during 1959. Mortality in the diseased stands increased in 1959, especially at the Prescott location where needle cast was severe from 1953 to 1956. Such mortality may be attributed to the cumulative weakening effect of needle cast followed by other agencies.

Trees	Prescott National Forest		Coconino National Forest	
	1958	1959	1958	1959
	- - - - - (Percent) - - - - -			
Diseased	58	59	72	78
Dead	11	16	0	1
With youngest diseased needles:				
1 year old	78	57	85	61
2 years old	20	41	7	37
	- - - - - (Number) - - - - -			
Basis:				
Living and standing dead stems	394		681	

Intensive study of needle cast fungi continued

Observations and laboratory studies of fungi associated with needle cast of ponderosa pine were continued on a reduced scale in cooperation with the University of Arizona. The University's Dr. Paul D. Keener found two additional non-hypodermataceous fungi in discolored needles. The first one, *Coryneum cinereum* Dearn., forms black fruiting bodies beneath the needle epidermis that resemble those produced by the brown spot fungus, *Lecanosticta acicola* (Thum.) Sacc. (fig. D-2). The general habit of the fungus is typical of *Coryneum* (fig. D-3) and it was the only associate of marked discoloration in scattered areas on the north rim of the Grand Canyon. The second fungus, either a *Phacidium* or a *Naemacyclus*, has fruiting structures that resemble large blistered areas until they erupt through the needle epidermis to expose cushion-shaped brown-black fruiting layers (fig. D-2). These structures were found on numerous needles throughout Arizona in 1959. A third type of fruiting was observed this year on the northern division of the Kaibab National Forest. This type had been seen previously on the Prescott. It is composed of black sclerotial masses that sometimes extend the entire

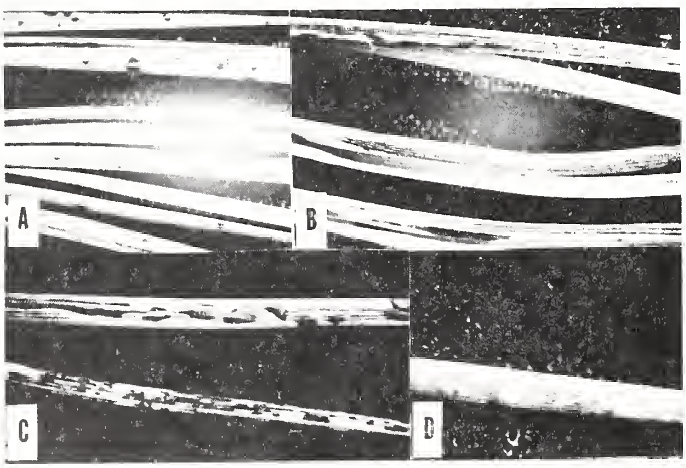


Figure D-2. --Fruiting areas on discolored ponderosa pine needles: A, Black cushion-like subepidermal fruiting bodies of *Coryneum cinereum* Dearn., north rim of Grand Canyon; B, black elongated sclerotial masses of an unidentified fungus, northern division of the Kaibab National Forest; C, Fruiting bodies of a fungus resembling a *Phacidium* or a *Naemacyclus*, Prescott National Forest; D, "Concolorous blisters" of *Hypodermella concolor* (Dearn.) Darker, Coconino National Forest.

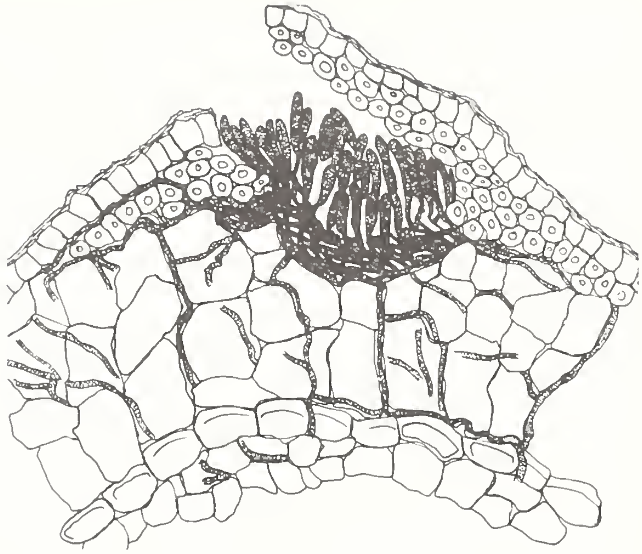


Figure D-3. --

Diagrammatic representation of transverse section of ponderosa pine needle showing the fruiting structure of Coryneum cinereum. North rim of Grand Canyon. Magnification: 180 times.

length of needles (fig. D-2) and are sterile or contain pycnidial-like initials. Apparently this pathogen could be an early stage of any one of several needle-inhabiting fungi. All three of these fungi are highly destructive to needle tissues; hyphae often replace the phloem elements of needles. Perithecia of Hypodermella concolor (Dearn.) Darker underlie the "concolorous blisters" shown in figure D-2. The "blisters" sometimes contain another fungus, which was designated as a Diplodia in the 1958 Annual Report. Additional study suggests that the fungus should be transferred from Diplodia to Davisiella because of its habitat.

New needle cast of blue spruce in Colorado

A needle cast of blue spruce, tentatively identified as Rhizosphaera kalkhoffi, was noted both in ornamental plantings and in natural-growth blue spruce. The disease is a slow killer that spreads from the lower branches upward and progressively kills the crown. The needle cast was originally described on blue spruce in the northeastern United States but was unknown in the native range of this tree.

STAINS -- DECAYS -- ROOT ROTS

Wetwood damages Wyoming cottonwood

Wetwood was unusually abundant and damaging in native narrowleaf cottonwoods in the South Fork of the Shoshone River near Cody, Wyoming. It appears to be the primary cause of high mortality in this area. Wetwood has not been studied in this region, but it is presumably caused by a bacterium that builds up pressure within the wood and forces sap out through splits in the bark. The only method of reducing this disease is to bore holes in the trunks and insert drains to relieve the pressure.

Navajo defect study extended to the Chuska Mountains Unit

Under the provisions of a new cooperative agreement between the Navajo Tribe, the U. S. Bureau of Indian Affairs, and the Rocky Mountain Station, this study of red rot in residual ponderosa pine stands was extended to the Chuska

Mountains Unit of the Navajo Indian Reservation. Field work started early in September 1959 and continued until weather conditions forced a halt. The study will be resumed in May or June 1960.

Study of red rot in young ponderosa pine was resumed

Twelve permanent sample plots on four national forests were reexamined in 1959 as part of a long-range study of red rot development in second-growth ponderosa pine. This was the second 10-year examination of the plots that were established in 1938 and 1939. They were limited to stands that were between 41 and 70 years old when the study was started. In addition to observations on mortality and remeasurements of d.b.h.'s, a 20-percent sample of pruned plot trees that were infected in 1938 and 1939 was dissected to measure the extent of rot penetration and decay in the trunk heartwood. In addition, two or more unpruned infected trees adjacent to each plot were also dissected. Sixty trees were dissected (33 pruned and 27 unpruned). Field isolations were made from all rot columns, but conclusions cannot be drawn until the results of the isolations have been checked in the laboratory.

Extent of aspen decay associated with sporophores

In 34 aspens from 5 localities of *Fomes igniarius* decay extended for an average of 15 feet above and below the highest and lowest conks. The first year's results revealed no relationship between the extent of decay and tree age, sporophore size, or sporophore height. However, number of sporophores was associated with amount of decay. It extended for an average of 14 feet above the highest conk in trees with 5 or fewer conks, and 19 feet in trees with 6 or more sporophores.

This work will be continued until data are obtained from all important aspen forests in Colorado.

Root rot kills young lodgepole pine

Root rot was common in lodgepole pine reproduction in northern Colorado and southern Wyoming. Isolations confirm that *Armillaria mellea* is involved as was suspected on the basis of symptoms. Counts made on mil-acre plots at 1-chain intervals in two young stands on the Roosevelt National Forest showed that about 6 percent of the trees had been killed:

Area	Mil-acre plots (Number)	Average age (Years)	Trees examined (Number)	Root rot killed (Percent)
1	98	13	371	6.7
2	60	14	98	6.1

Although a small proportion of the stands is now infected, infection centers are distributed throughout most young lodgepole pine stands. A total of 63 infection centers were examined and permanently marked so that the annual progression of the disease can be determined. The number of trees killed in the infection centers ranged from 1 to 45.

Control tests are planned for this potentially dangerous root rot.

FOREST UTILIZATION

Ponderosa pine poles meet specification standards

Interest in the establishment of a ponderosa pine pole production industry in Arizona led to testing a sample of the available pole timber by a prospective producer. The purpose of the test was twofold: to evaluate the quality of the timber for pole production, and to obtain customer reaction to ponderosa pine poles in the Southwest.

The sample was selected from the Prescott National Forest, site of the proposed plant. It consisted of 110 poles of various sizes and classes. The poles were peeled and graded. Grading was done according to American Standard Association specifications for wood poles. Of the 110 poles tested, 107 met the specifications. Three were rejected because of the presence of red rot.

Following peeling, the poles were seasoned by the vapor-seasoning method after which they were treated according to treating specifications of the American Wood-Preservers' Association (fig. U-1). The poles appeared to season well by the vapor-seasoning method. There was no evidence of any serious checking (fig. U-2), and the poles readily accepted creosote. The results of vapor seasoning and treatment of the two charges are shown in table U-1.

Figure U-1.--(right)

Ponderosa pine poles after vapor seasoning and treatment.

Figure U-2.--(left)

Ponderosa pine poles showing the small amount of checking that results from vapor seasoning and treatment.

Table U-1. --Results of vapor seasoning and treating tests

Item	Unit of measure	Charge No. 1	Charge No. 2
	VAPOR SEASONING		
Volume of poles	Cubic feet	556	960
Time vapor dried	Hours	11	13.25
Temperature	° F.	300	290
Hot vacuum:			
Time	Hours	2	2
Vacuum	Inches	24	24
Moisture content:			
Green	Percent	60.0	60.0
Dry	Percent	24.9	24.0
	CREOSOTE TREATMENT		
Air pressure:			
Time	Minutes	20	20
Pressure	Pounds	100	95
Solution pressure:			
Time held	Hours	4	3
Pressure	Pounds	190	190
Final vacuum:			
Time	Hours	1	1
Vacuum	Inches	23	24
Solvent recovery:			
Time	Minutes	(Not	80
Temperature	° F.	applied)	285
Vacuum	Inches		24
Net retention	Pounds per cubic foot	10.10	8.69

The classes and lengths of poles developed from the sample are shown in table U-2.

Table U-2. --Classes and lengths of poles

A. S. A. pole class	Length (feet) 22	25	30	35	40	45	Total
				Number			
2	0	2	1	0	0	0	3
3	0	0	0	0	1	1	2
4	0	0	2	4	1	1	8
5	2	1	4	4	5	2	18
6	1	2	10	8	4	2	27
7	1	3	11	25	8	1	49
Total	4	8	28	41	19	7	107

Region 6 ponderosa pine log-grading system effective in grading Arizona ponderosa pine

A study of ponderosa pine lumber grade recovery at Flagstaff showed that the R-6 ponderosa pine log-grading system was applicable for determining log quality of this species in the Southwest. Figure U-3 presents the relative value of the lumber recovered from the study logs segregated by this log-grading system. Average 1958 selling prices for ponderosa pine lumber in Region 3 were used in determining lumber-recovery values for the study logs.

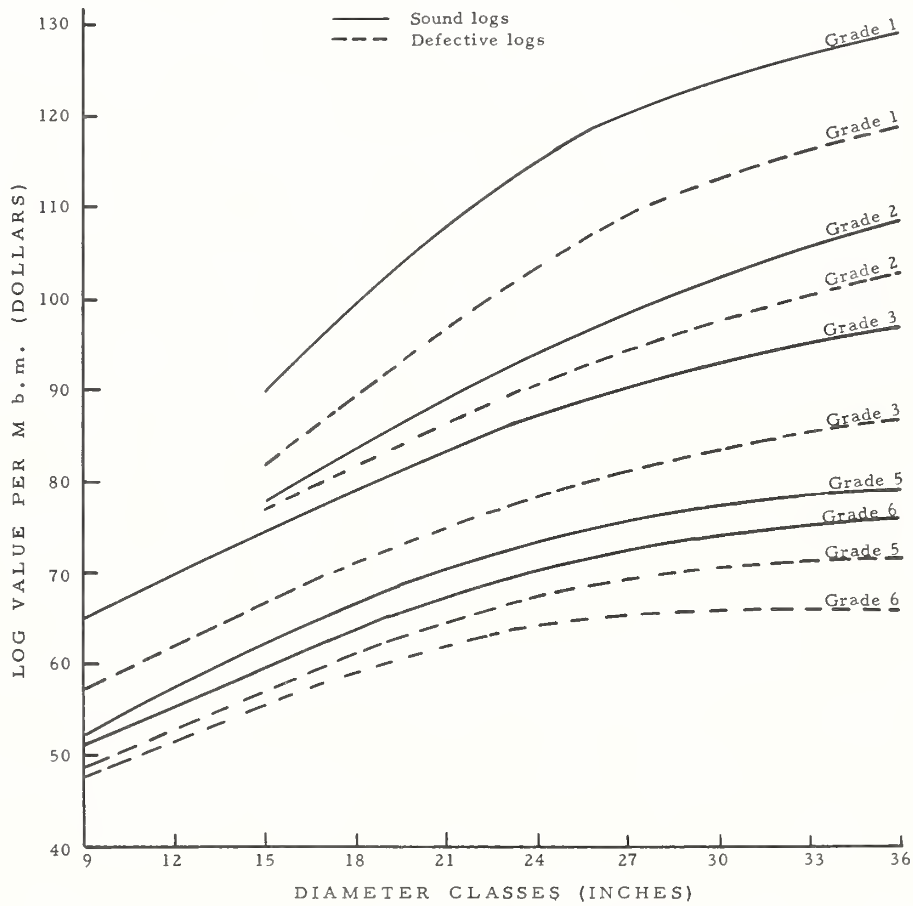


Figure U-3.--Relative value of logs of different grades, diameters, and degrees of soundness, based on lumber tally.

As can be noted further in figure U-3, there is a marked difference in recovery value between sound and defective logs of the same grade and diameter. For example, sound grade 1 logs have recovery values ranging from $7 to $11 more per M board feet than defective logs of the same grade and diameter. Grade 6 includes the logs of lowest recovery value based upon the R-6 grading system. The recovery value of sound logs in this grade exceeds that for comparable defective logs by approximately $4 to $10 per M board feet.

Modification of the R-6 ponderosa pine log-grading system to include allowance for scalable log defects such as sweep, catfaces, and pitch concentrations, would tend to eliminate the recovery value differences between sound and defective

logs as shown in figure U-3. This problem is being considered by the Interregional Ponderosa Pine Log and Tree Grade Project. Figure U-4 compares lumber recovery for sound and defective logs of the same log grade and further illustrates the yield differences due to log soundness.

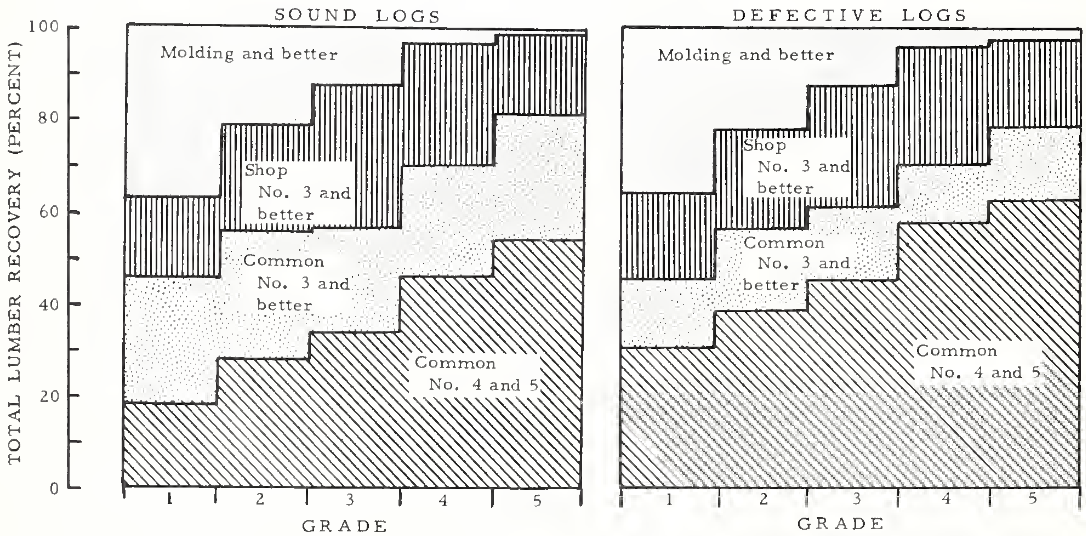


Figure U-4. --Lumber recovered by lumber grades for sound and defective logs.

For all log grades, the sound logs yielded from 1-1/2 to more than 2 times as much high-common-grade lumber as did the defective logs. Conversely, the defective logs yielded considerably more low-common lumber than sound logs of the same grade.

As would be expected, defective logs produced more overrun than sound logs of the same grade. Figure U-5 presents the comparison of overrun from sound and defective logs by log grade.

Seasoning and surfacing reduce ponderosa pine lumber grades and volumes

Seasoning and surfacing adds value to lumber, but these processes result in grade changes and volume losses in bringing the lumber to a shipping or marketing condition.

All lumber produced from the Flagstaff study logs was graded and tallied in the green condition to record the recovery from individual logs. Thus, to arrive at the shipping tally grade and volume, it was necessary to adjust for the grade and volume changes resulting from seasoning and surfacing. These data were obtained by regrading and tallying representative samples of all lumber sawed in the study and applying the results to the green volumes.

Aggregate volume loss resulting from seasoning and surfacing of the lumber from the study logs amounted to 4.3 percent of the green recovery volume.

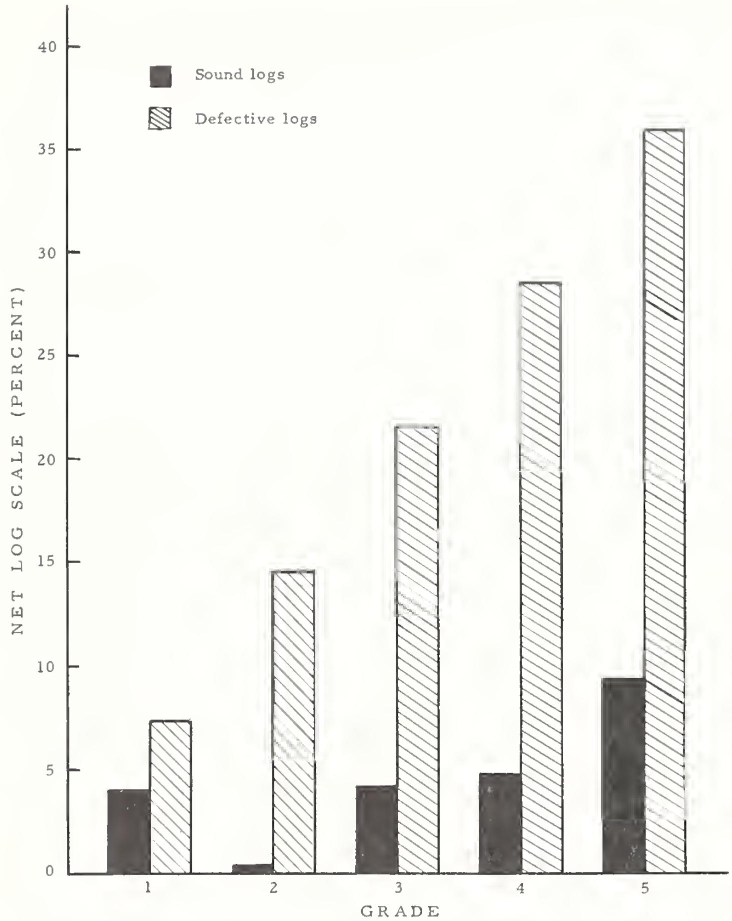


Figure U-5. --Overrun by log grades for sound and and defective logs.

Change of grade due to kiln drying and surfacing of the study lumber is presented in table U-3. The original, or rough green grade, is shown at the left in the table. Distribution of the lumber in the final grading is expressed as a percentage of the shipping tally recovered for each grade sample.

Table U-3. --Change of lumber grade from green grade to shipping tally

Rough green grade	Shipping tally grade													
	Selects			Molding	Clear No. 3	Shop			Commons					Total
	B & better	C	D			No. 1	No. 2	No. 3	No. 1	No. 2	No. 3	No. 4	No. 5	
	Percent													
Selects	8.6	11.8	58.8	12.0	0.5	1.0	5.8	0.4	0.5	0.3	0.3	--	--	100.0
Molding	0.3	0.6	3.3	70.0	4.9	14.3	3.5	1.5	--	--	.8	0.6	0.2	100.0
Clear, No. 3	.2	.5	1.6	1.3	43.1	34.6	2.2	.7	--	.5	4.9	9.0	1.4	100.0
Shop:														
No. 1	--	.3	1.3	.4	8.1	41.8	20.5	7.5	--	--	1.5	15.8	2.8	100.0
No. 2	--	--	1.0	.5	--	2.0	52.4	37.5	--	--	--	3.3	3.3	100.0
No. 3	--	--	--	--	--	.6	28.3	66.0	--	--	--	3.1	2.0	100.0
Common:														
No. 2 & better	--	--	.5	.5	.7	--	--	--	1.5	47.2	47.5	2.1	--	100.0
No. 3	--	--	.2	--	.3	1.4	--	--	--	1.1	65.6	30.2	1.2	100.0
No. 4	--	--	.3	.1	.5	1.9	--	--	--	.1	11.3	70.0	15.8	100.0
No. 5	--	--	.1	--	.2	1.7	--	--	--	--	3.3	20.1	74.6	100.0

Circular sawmills equipped with resaws excel in lumber production and in sawing accuracy

A study of the production performance of circular-type sawmills in the Black Hills revealed that mills equipped with horizontal band resaws or cant sash gang resaws had higher lumber production rates and saw more accurately than mills with no resaw (table U-4). The sawmills with the band resaw and the gang resaw produced 54 to 75 percent more 4/4 lumber per hour than did a mill with a circular head rig and no resaw. The greater lumber production at the mills with the resaws was due primarily to less time used in sawing a log. As shown in table U-4, the mill with a horizontal band resaw had the shortest sawing time per thousand board feet and the highest production rate per hour. Sawmills with circular head rigs and resaws cut most of their lumber from cants or from slabs and sections of logs. Therefore, less time is required for the circular head rig to break down a log for resawing than when the whole log is cut into 4/4 lumber on the circular head rig.

Table U-4. --Lumber tally per hour and distribution of sawmill operating time at three kinds of sawmills in the Black Hills

Kind of sawmill	Average log diameter	Lumber tally per hour (delay included)	Distribution of time: Sawing	Between logs	Non-operating (rest, breakdowns, and maintenance)	Total
	Inches	Board feet	- - - - Minutes per M b.m. - - - -			
Circular head rig and horizontal band resaw	12.0	2,988	11.65	6.31	2.12	20.08
Circular head rig and sash cant gang resaw	10.1	2,634	17.60	3.91	1.27	22.78
Circular head rig and no resaw	10.5	1,709	26.68	6.15	2.27	35.10

Another advantage of the horizontal resaw and gang resaw is that they reduce waste. The resaws have thinner saws than circular head rigs and they usually cut thinner slabs. For example, the mills with the horizontal band and gang resaws will, on the average, cut 68 board feet from a 10-inch-diameter, 16-foot-long log; whereas, a circular mill will cut 63 board feet, or a difference of 5 board feet. This difference is even greater for larger logs. For a 20-inch log the mills with resaws cut 21 board feet more than the circular mill. The relationships between lumber recovered and log diameter for sound 16-foot logs cut by the two kinds of sawmills can be expressed by the following formulas:

Horizontal band and cant sash gang resaw mills

$$Y = -0.21136 + 2.04662X$$

Circular head rig with no resaw

$$Y = -0.24391 + 2.04662X$$

Where:

Y = logarithm of dry lumber recovered
X = logarithm of log diameter

Lumber cut by a cant sash gang resaw was more uniform in thickness than the lumber cut by a horizontal band resaw or by a circular head rig mill with no resaw (fig. U-6). Thickness measurements of green lumber cut by a gang resaw averaged 33/32 inches, and 97 percent of the measurements were within a 6/32-inch variation. The measurements of lumber cut by a band resaw averaged 33/32 inches, and 93 percent were within a 6/32-inch variation. At the circular mill, thickness measurements averaged 34/32 inches and 89 percent were within a 6/32-inch variation. The variation of lumber thickness at all three mills was within the specifications of the Western Pine Association.

There was no significant difference in the amounts of select lumber cut by the three mills from similar quality logs. This is based on results of comparisons of the amounts of select grades of lumber from grade 1 and grade 2 logs, 10 to 14 inches in diameter cut at the three mills.

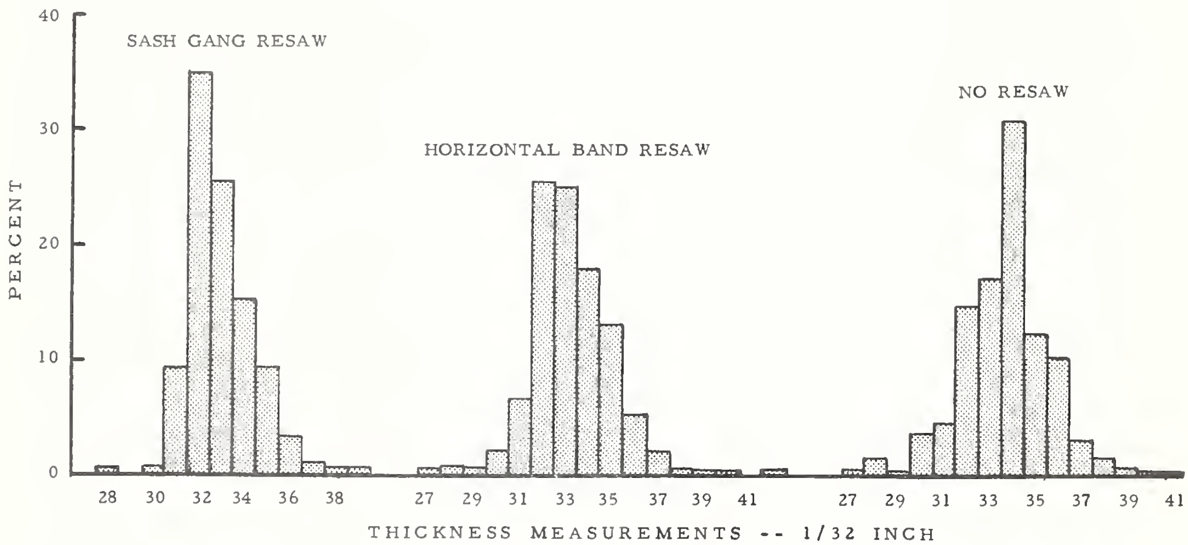


Figure U-6. --Distribution of thickness measurements on rough green lumber cut at three Black Hills sawmills- -two with circular head rigs and resaws and one with circular head rig and no resaw.

Saw logs make up 90 percent of timber cut in Black Hills

The sawmill industry is the largest user of timber in the Black Hills (table U-5). In 1958 the sawmills used about 90 percent of the timber cut from national-forest, State, and private lands, or a total of 67 million board feet, Scribner scale. The post, pole, and pulpwood industries used the remaining 10 percent, or about 16, 000 cords of below-saw-log-sized trees.

The sawmill industry consists of 50 sawmills. Of these mills, 43 have circular head rigs and cut one-half of the 67 million board feet. The remaining one-half was cut by 7 sawmills having circular head rigs and resaws. The annual lumber production capacity of these 50 mills is about 102 million board feet, Scribner scale, if all mills run full time. However, not all of the sawmills are financially able, nor do some of them desire to run full time. Therefore, a realistic annual capacity would probably be less than 102 million board feet. During the fiscal year 1959 (July 1, 1958, to June 30, 1959) the lumber market

Table U-5.--Output of timber products in the Black Hills, 1958

Timber products	Volume used		
	Standard units	M cu. ft.	Percent
Saw logs	67,202 M bd. ft.[1/]	[2/]11,200	90
Posts	833 M pieces	600	5
Poles	98 M pieces	343	3
Pulpwood	3,406 cords[3/]	259	2
Total		12,402	100

1/ Scribner log scale.
2/ 6 board feet per cubic foot.
3/ Rough cord = 128 cubic feet;
solid wood content = 75.9 cubic feet.

was good and the sawmills increased their production considerably. During this period the mills cut about 64 million board feet from national-forest land and approximately 17 million board feet from State and private lands. This production of 81 million board feet was the largest ever recorded for a similar period during the past 39 years. It approximately equals the total sustained yield for the area, which is estimated at 80 million board feet.

The post and pole industry consists of eight plants. In 1958 these plants produced a total of 833,000 posts and 98,000 poles, or a total of about 12,000 cords. About 70 percent of the posts and poles produced were creosote pressure treated. The remaining 30 percent were produced by one osmosalts pressure plant, two penta cold-soaking full-length plants, one creosote hot- and cold-bath full-length plant, two osmoplastic butt-treating plants, and one operation producing untreated peeled poles for shipment to a treating plant outside the area. The combined annual capacity of the treating plants is about 30,000 cords, or 25 percent of an estimated 120,000 cords of below-saw-log-sized trees available. In 1958 the post and pole plants used about 10 percent of this available resource.

Pulpwood is the basis for the newest forest industry in the Black Hills and is now the major user of below-saw-log-sized trees. The industry started in 1955, when about 300 cords of pulpwood were shipped to a Lake States pulp and paper mill. Small trial shipments were continued each year until 1959 when a considerable increase in shipments occurred. An estimated 20,000 cords of pulpwood will be shipped in 1959. Currently, most of the pulpwood is being shipped by one pulpwood company operating in the northern and eastern Black Hills.

Sawmill and logging residues are currently being used in small amounts at the sawmills. Several mills make lath from the slabs and edgings, and some burn sawdust and shavings to supply dry kilns with steam. However, there are no forest industries other than the sawmills that use sawmill and logging residues as a raw material.

The greatest amount of timber available for forest industry growth is in the below-saw-log-sized trees. The combined post, pole, and pulpwood industries probably will use about 32,000 cords. This will leave a surplus of 88,000 cords of below-saw-log-sized timber that would be available. At the 1959 rate of saw-log use no surplus of sawtimber would be available for expansion of the sawmill industry.

Skyline-crane logging trials pass quarter million board feet

An overhead cable system for logging steep, remote timberland with a minimum of roads is being tested on the Fraser Experimental Forest in Colorado. A Wyssen Skyline-crane, Model W-30 with 2-ton capacity, was installed July 1955 on West St. Louis Creek, 3 miles from the Fraser Experimental Forest headquarters. This equipment not only skids and yards logs, but transports them via skyline crane to a roadside landing (fig. U-7).

Figure U-7. --

Logs are transported on a skyline cable to a landing.

Two cutting strips were logged during the current study. Each cutting strip was one-half mile long and more than 300 feet wide. Engelmann spruce made up 90 percent of the volume. Subalpine fir made up the remainder in stands varying from 6,500 to 16,000 board feet per acre. Slope gradient varied from 10 to 90 percent with an average gradient of 48 percent. Most of the sale area was so steep it could not have been logged safely or efficiently with horses or tractors.

Each cutting strip was divided into 4 blocks, each containing 5 acres. Selection cutting, where 15 percent of the volume was removed, was practiced on 3 blocks. All logs were cut to a maximum length of 16 feet. Average volume per log was 60 board feet (16 logs per M board feet) on clear-cut areas and 80 board feet (13 logs per M board feet) on selection-cut areas.

Costs for selective logging were higher than those for logging the clear-cut blocks. Most of the increase in costs were caused by lower timber volumes resulting in higher installation charges. Sufficient timber per setting must be available to keep the fixed costs of installation as reasonable as possible.

Total cost of 260,000 board feet of logs delivered to the landing from clear-cut blocks was little more than $36 per thousand board feet as shown in the tabulation:

			Cost per M board feet (16 logs/M bd. ft.)
Operating costs:			
Labor (includes variable wages for laborers and engineers averaging $1.81 per hour) --			
Yarding and skidding	$12.80		
Rigging (does not include fixed installation charges; only normal rigging work associated with logging)	1.82		
Maintenance (lubrication, mechanical adjustments, landing work, etc.)	1.48		
Breakdown (primarily for severe electrical storms)	1.70		
Weather	.39		
Total labor		$18.19	
Gasoline, oil, and lubricants		.29	
Reserve supply fund (includes parts supply and operating cable replacement fund)		3.00	
Depreciation account		1.00	
Total operating costs			$22.48
Felling and bucking			6.60
Stumpage			3.00
Installation labor costs			4.09
Total f.o.b. landing			$36.17

The installation charge is based upon nearly one-half million board feet that could have been logged from both strips if all blocks had been clear cut.

Overhead cable systems have several advantages over conventional logging methods. Entire timbered drainages can be logged with a minimum of roads and equipment. Logs can be skidded and transported over cableways for distances up to 1-1/2 miles without heavy investments in roads or other auxiliary logging equipment. On valuable watersheds subject to erosion, the skyline cable logging system offers the opportunity to log timber with negligible soil disturbance. Timber can be removed in any desired pattern to fit the needs of both watershed managers and silviculturists.

On the negative side is the difficulty of maintaining a properly trained crew. Because of the steepness of the topography involved, the work of felling, bucking, and setting chokers is more difficult than on other shows, especially under wet conditions. This has resulted in considerable turnover and made it difficult to accomplish the specialized training that the system requires. Other items in this category concern equipment design and modification in order to better adapt the system to local conditions. Solution of the latter is largely a matter of adequate financing.

Overhead cable-logging tests using the Wyssen skyline-crane are continuing. Efforts are being made to better adapt the equipment to central Rocky Mountain timber, topography, and woods-labor conditions.

Junipers show high natural decay resistance in fencepost study

During 1938-40, a comprehensive study was undertaken to test 14 southwestern species for use as fenceposts (table U-6). Several preservatives and treating methods were tried.

The fencepost study has several objectives. Natural durability is singled out for reporting at this time.

As can be noted in table U-6, the various juniper species showed the longest life expectancy, ranging from 27 years for Utah juniper to 35 years for the one-seeded juniper. A rather unusual result is the large spread of service life between aspen and ponderosa pine. Both of these species are classified as nondurable. The relatively small difference between ponderosa pine and pinyon is also of interest in that the high pitch content of pinyon is sometimes credited with having preservative value.

The test sites included locations in Arizona and New Mexico and sampled irrigated desertland, semidesert, and forested plateau. The data are reported as of the latest inspection date--November-December 1958--or after approximately 20 years of service.

Table U-6. --Natural durability of southwestern species as fenceposts

Species	Location 1/	Posts in test	Service	Posts serviceable (1958 inspection)		Expected average life 2/
		No.	Years	No.	Pct.	Years
Aspen (Populus tremuloides)	B, C	10	19.25	1	10.0	15.00
Arizona cypress (Cupressus arizonica)	A, B, C	123	19.30	75	61.0	21.00
Alligator juniper (Juniperus deppeana)	A, B, C	103	18.85	96	93.2	33.00
One-seed juniper (J. monosperma)	A, B, C	94	18.99	88	93.6	35.00
RockyMountain juniper (J. scopulorum)	A, B, C	70	19.25	62	88.6	28.00
Utah juniper (J. osteosperma)	A, B, C	103	19.38	91	88.3	27.00
New-Mexican locust (Robinia neomexicana)	B	34	18.00	22	64.7	21.00
Mesquite (Prosopis juliflora)	B	35	18.00	17	48.6	19.00
Arizona white oak (Quercus arizonica)	B	27	18.00	8	29.6	17.00
Emory oak (Q. emoryi)	B	11	10.45	0	0	3/ 10.45
Gambel oak (Q. gambelii)	B, C	73	18.60	56	76.7	24.00
Silverleaf oak (Q. hypoleucoides)	B	43	9.29	0	0	3/ 9.29
Ponderosa pine (Pinus ponderosa)	B, C	45	5.66	0	0	3/ 5.66
Pinyon (P. edulis)	B, C	10	6.24	0	0	3/ 6.24

1/ A = irrigated desert; B = semidesert; C = wet plateau.
2/ Determined from mortality curve.
3/ Actual average service life.

Temperature soars to 170° F. in house temperature study

A study undertaken to determine the temperatures that wood framing members are exposed to in houses in the desert Southwest revealed that temperatures of 170°F. can be expected. The study is part of a nationwide program sponsored by the U. S. Federal Housing Administration for the purpose of developing specifications for laminated dimension material. The Southwest study is being conducted cooperatively with the University of Arizona and the Forest Products Laboratory at Madison, Wisconsin.

By means of thermocouples and an automatic temperature-recording instrument, temperatures were determined at the surface and at various points through the wall and roof sections. To develop maximum temperatures, the thermocouples were located in south or southwesterly exposed sections. The readings were taken during June, July, August, and September. The study was confined to all-wood houses, or sections of all-wood construction, but which otherwise exemplified major housing trends. The data are currently being compiled.

Native adobe performs well as charcoal kiln material in southern Arizona operation

One of the major weaknesses of masonry material for charcoal kiln construction is its tendency to crack. Cracks not only weaken the structure but also interfere with draft and temperature control. Kilns constructed of native adobe in a southern Arizona operation (fig. U-8) have exhibited a high resistance to cracking. The kilns have been in continuous operation for 5 years without any major maintenance. The material, while considerably weaker structurally than cement, is apparently more stable dimensionally or has the property to yield to dimensional changes.

The Arizona kiln was installed to help reclaim rangeland that has been invaded by mesquite. As can be noted, from the remnant of the stand shown in the background of the photo, mesquite reach tree size in the river bottoms. Mesquite of this size is a desirable raw material for charcoal production, as the $6 per cord harvesting cost indicates.

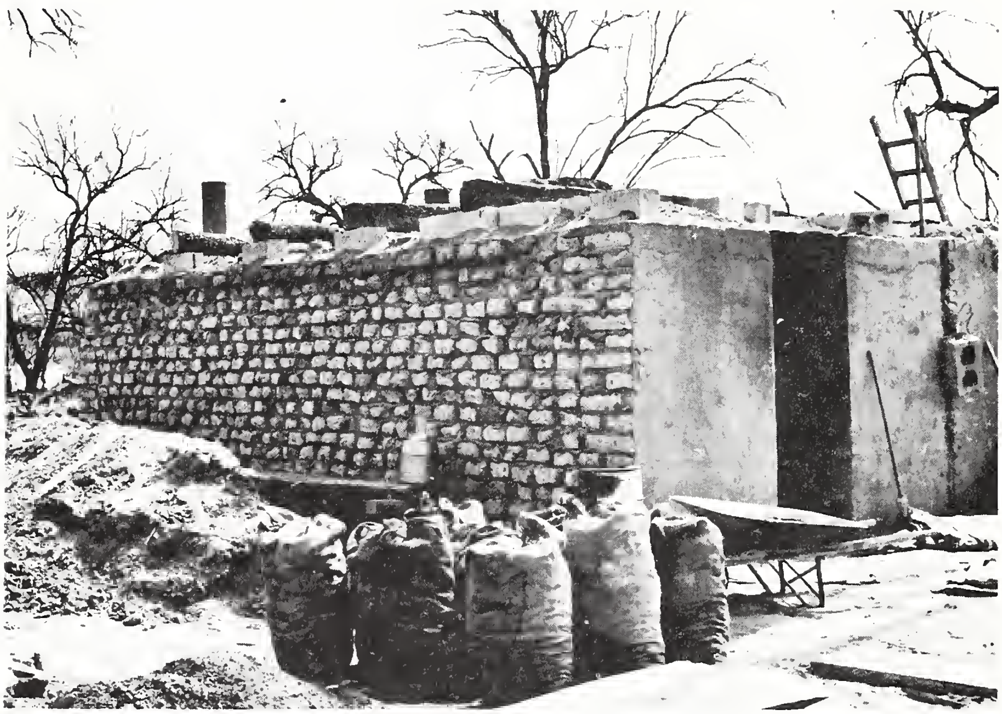


Figure U-8. --Charcoal kiln constructed of native adobe. Plastered front helps seal door.

FOREST ECONOMICS RESEARCH

FOREST SURVEY

Inventory phase of timber survey completed in Colorado

All remaining volume sample plots on the Arapaho, Grand Mesa-Uncompahgre, Gunnison, White River, San Juan, and Rio Grande National Forests and on areas outside of national forests were cruised. This completes the timber inventory field work in Colorado.

Forty-seven million dollar output of primary wood products in 1958

Estimates of output and prices of primary wood products in the 7-State area including Arizona, Colorado, New Mexico, Wyoming, South Dakota, Kansas, and Nebraska indicated a total output value at local points of delivery of about $47 million. The States ranked in the order given in value of output. The production of more than 900 million board feet of sawlogs (International 1/4 rule) accounted for four-fifths of the total value. Other products included veneer and cooperage logs or bolts, pulpwood and excelsior bolts, fuelwood, posts, timbers for mines and farms, utility poles, and converter poles.

Census completed on 1958 lumber manufacture in Arizona and New Mexico

A census of lumber production in 1958 in Arizona and New Mexico was carried out in cooperation with the U. S. Bureau of the Census. Reports of lumber manufacture in the two States are being prepared by the Census Bureau.

Use of wood in transportation surveyed

As part of a study of national timber requirement, data on the volume and kinds of wood used in packing, crating, and transportation were obtained from a sample of firms in the central Rockies and Plains area. The principal uses of wood were found to be hardwood flooring and Douglas-fir plywood for trailer repairs, and pine and Douglas-fir lumber for packing boxes and crating.

Logging residue volumes estimated

Field plots have been completed on five operations as part of a study of sawtimber logging residues in Colorado and Wyoming. A preliminary analysis indicates net residues for these operations of about 4 percent of the utilized net board-foot volume and 7 percent of the utilized net cubic-foot volume.

Pulpwood supply presents large opportunity to industry, local economy, and forest management

More than 27 million cords of pulpwood may be tributary to potential pulpmill sites along the Colorado River in a west-central Colorado study area (fig. E-1). This is the interpretation given to preliminary Forest Survey data for the several national forests in the area. This wood supply is made up of lodgepole pine pole-timber; insect-killed and live Engelmann spruce, both sawtimber- and pole-sized; aspen, also sawtimber- and pole-sized; and some subalpine fir, mostly pole-sized.

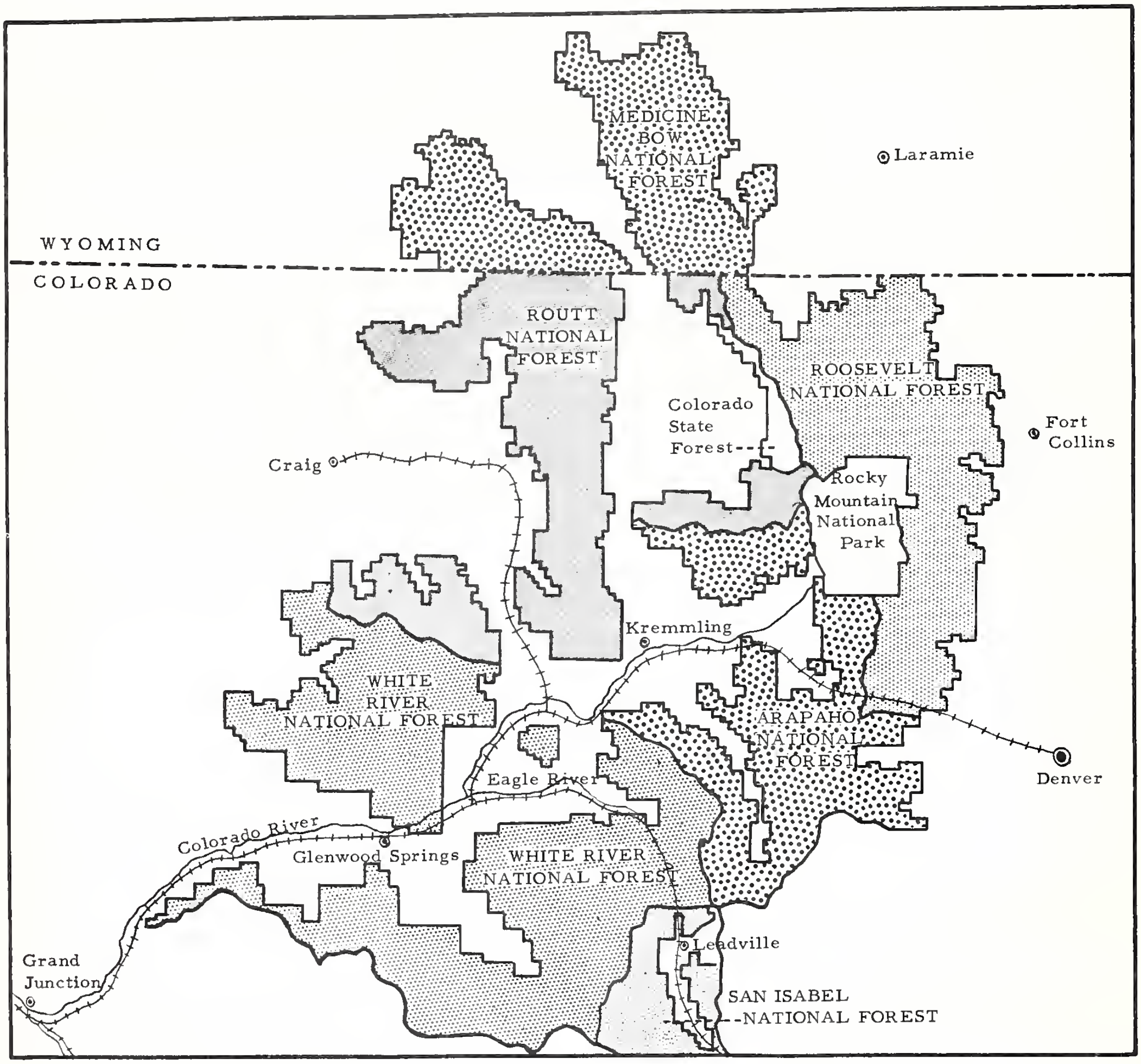


Figure E-1. --Study area.

Preliminary volume estimates by national forest and species type are shown below. Types may be composed of more than one species and size-class. For example, the aspen type contains both poletimber and sawtimber-sized trees. It also contains some coniferous species such as Engelmann spruce and subalpine fir. However, the dominant species of the type is aspen, based on cubic-foot volume.

	Lodgepole pine	Aspen	Engelmann spruce	Total
	- - - - - (Thousand cords) - - - - -			
Medicine Bow	4,004	--	--	4,004
Roosevelt	3,204	--	--	3,204
Routt	2,856	2,098	2,988	7,942
White River	1,477	2,482	4,878	8,837
Arapaho	2,331	--	--	2,331
San Isabel	1,000	--	--	1,000
Total	14,872	4,580	7,866	27,318

These volumes alone represent a pulpmill capacity of 1,500 to 3,000 tons of pulp a day for a 30-year operation, depending upon pulping process used. If paper mills were established in conjunction with the pulpmills, this capacity would represent pulp and paper logging and manufacturing employment for 4,000 to nearly 11,000 people.

The possibility for management is equally challenging, since this pulpwood resource is made up of more than 1,600,000 acres of commercial forest land.

Water will be a limiting resource factor in pulpmill development

A study of the water aspects of this potential development on the Colorado River is being conducted cooperatively by several interested agencies. In the opinion of State officials, there are adequate volumes of unappropriated surface water for industrial use below the confluence of the Eagle and Colorado Rivers. Although this surface water is generally plentiful, it will probably be the limiting factor in pulpmill development because of the pollution equivalents of chemical pulping processes. An initial appraisal reveals that only the Colorado River has sufficient water to tolerate feasible-sized chemical pulpmills. Small-capacity groundwood mills could be supported by tributaries. Thus, there are few alternatives for pulpmill sites.

Quality of process water will present some minor problems to be overcome by industry. Colorado River water below the confluence of the Eagle River is relatively hard in terms of calcium carbonate for the manufacture of fine paper, bleached kraft paper, soda and sulfate pulps. It is also moderately alkaline for the production of these products. Total dissolved solids are also present in somewhat excessive amounts, without treatment, for use in the manufacture of fine paper, bleached kraft paper, soda and sulfate pulps. Excessive water color will be another minor problem during the spring months above the confluence of the Eagle and Colorado Rivers.

WATERSHED MANAGEMENT RESEARCH

This year's report starts with research dealing with the effect of wind on snow accumulation and melt. We hope to learn how wind can be used to create snowdrifts in locations where evaporation losses will be at a minimum and where melt will occur at the time of greatest water demand.

Also described is a new study on high-altitude sagebrush lands of northwestern Wyoming. Here, we are hoping to learn the effects of sagebrush removal on streamflow and sediment yield.

From the pine and juniper forests, we are reporting results of studies aimed eventually at altering the vegetation in such a way as to reduce evaporation and transpiration losses. A wildfire in Arizona demonstrated the tremendous erosion potential in mountainous land without protective plant cover.

The last section of the report deals with new findings in a study aimed at learning how to control phreatophytes by changing their environment.

Wind movement has an important effect on snow accumulation in forests

Figure W-1. --Snow intercepted by tree canopies is not always lost. In the Sangre de Cristo Mountains of northern New Mexico, considerable wind movement follows snowstorms, and the intercepted snow is blown from the tree crowns and redistributed over adjacent areas.

Figure W-2. --Some of the snow which is redistributed by wind accumulates as cornices in the lee side of windswept ridges such as the one shown here. One of the objectives of our research program, in forests such as these, is to learn how to manage the cover so that such drifting is increased (Sangre de Cristo Mountains).

Figure W-3. --In this pattern of snow redistribution, snow has been swept from bare rocky areas and accumulated in adjacent timber. Again this provides a cue to managing the forest so that snow will be concentrated into deep drifts, which will melt slowly and provide a source for late-season streamflow (Sangre de Cristo Mountains).

Frozen soil speeds surface runoff on south aspects

Figure W-4. --Surface runoff over frozen soil is shown in this road cut in the Sangre de Cristo Mountains, New Mexico. Warm daytime temperatures on a south-facing slope caused melting of the snow cover, with consequent exposure of bare soil. Subsequent cold weather froze the exposed soil to depths of 5 inches. Thereafter snowmelt water could not percolate through the soil mantle but instead moved downslope through the litter, humus, and surface inch or two of soil. Soil remained frozen on open and aspen-covered south slopes during most of the 1958-59 winter period.

Studies such as this help provide an understanding of the contribution that various slopes and aspects make to streamflow--an important consideration in good watershed management.

Aerial snow cover mapped during the runoff season

Table W-1. --Snow cover by type and aspect as mapped from Greens Peak, Arizona

Date of mapping 1959	Flat grassland	Conifer timber		Aspen	
		North-facing	South-facing	North-facing	South-facing
	Percent of snow cover				
March 12	90	100	75	100	75
March 19	65	100	50	100	75
March 31	10	100	40	80	25
April 14	5	85	0	10	25
April 22	0	75	0	0	0

Figure W-5. --Snow cover from Greens Peak in eastern Arizona, March 19, 1959. Greens Peak lies on the divide between the Salt and Little Colorado Rivers. Periodic photographs and snow-cover maps were used in this area to characterize snowmelt and learn the importance to streamflow of snowmelt from different types and aspects. Snow cover is summarized in table W-1.

Due to light snowpack in 1959, there was little flow in the Salt River. The high peak for the spring was 350 second-feet. It took place when most of the snow was gone except from the north-facing conifer stands. The timing of runoff in relation to snow disappearance was similar on the small watershed of the East Fork of Willow Creek (table W-2; fig. W-6).

Table W-2. --Snow cover for a key area near the middle of the East Fork of Willow Creek watershed, eastern Arizona

Date of mapping 1959	South slope	North slope	Meadow
	- Percent of snow cover -		
March 13	5	100	100
March 20	2	100	90
March 27	0	100	80
April 3	0	75	0
April 11	0	30	0
April 17	0	15	0
April 24	0	3	0

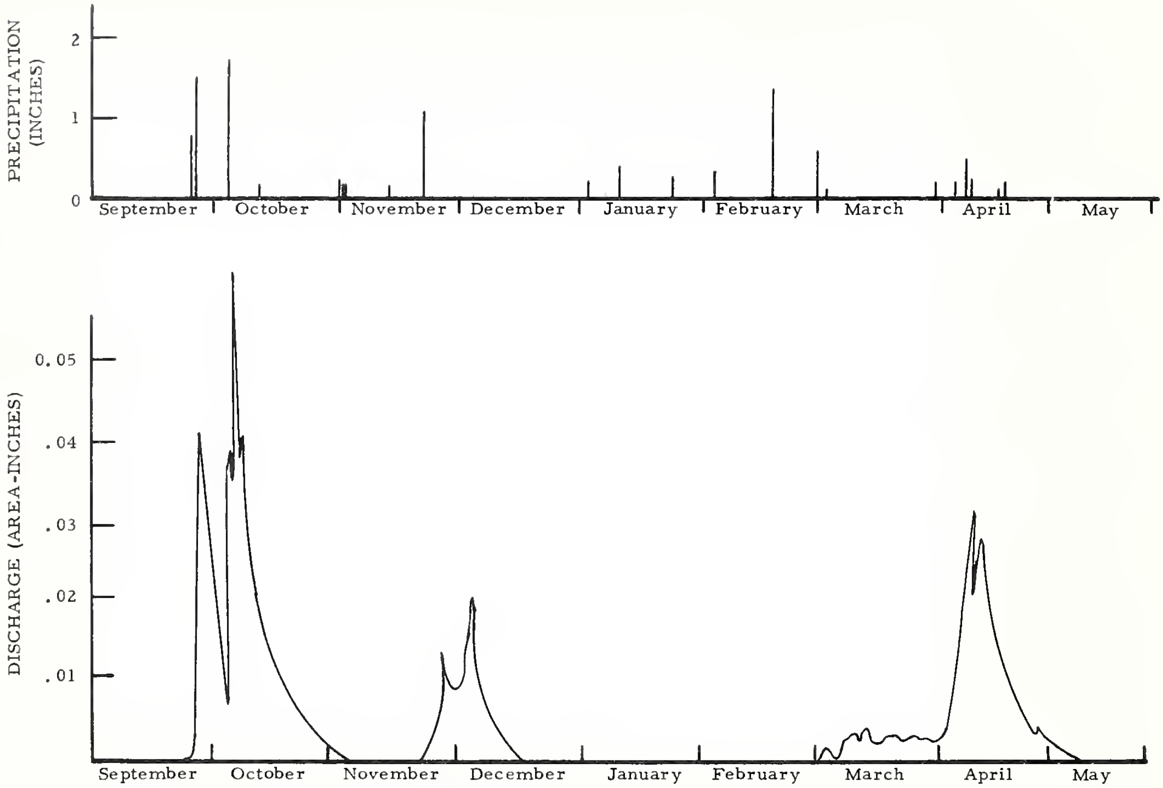


Figure W-6. --Precipitation and stream discharges on the East Fork of Willow Creek, Arizona, 1958-59. The discharge during March, April, and May was mostly from melting of snow, which accumulated in January and February; this amounted to about a third of the year's water yield.

Alpine temperature and wind

Wind patterns are complex in the high mountain areas. A ridge west of the alpine research site (fig. W-7) offers protection from the direct onslaught of storm winds. It also channels the winds and increases turbulence. Mean monthly wind velocities at the research site seldom exceeded 10 miles per hour, and from May until October 1958, monthly velocities were only about 5 m.p.h.

When the winds were analyzed on the basis of 6-hour periods, a more pronounced pattern appeared. The mean velocity for the windiest 6-hour period of each month was found to be from 2.0 to 3.3 times the mean monthly velocity. The maximum 6-hour velocity was 31 m.p.h. recorded on April 4, 1958, and during one 5-minute period on December 12, 1958, a sustained velocity of 60 m.p.h. was recorded.

Winter temperature extremes at the alpine weather station have varied between -19°F. and +38°F., both extremes occurring during the month of January. Average monthly minimum winter temperatures were between 3°F. and 12° F.; average maximums, between 15°F. and 20° F.

Summer temperatures averaged 45°F. to 49°F. with monthly maximum temperatures averaging 53°F. to 59°F. and monthly minimums averaging 35°F. to 42°F. Seven summer nights had temperatures at or below freezing; however, minimum temperatures averaged above freezing during June, July, August, and September. This means the late-lying snowfields are subject to melting temperatures both day and night for this 4-month period.

Figure W-7.--Year-round weather records have been taken at this alpine weather station since November 1957. The station is located west of Denver, Colorado, at an elevation of 12,000 feet.

Figure W-8.--Wind serves a useful purpose in alpine areas by redistributing incoming snowfall into drifts. The drifts melt slowly during the summer months and are a primary source of streamflow during this period of high water demand. A part of our alpine research program is directed toward taking advantage of the wind to increase drifting to the greatest possible extent by erecting man-made barriers such as the snow fence pictured here.

Hydrologic effects of sagebrush removal to be studied in Wyoming

In 1959, a study to determine the effect of sagebrush removal on streamflow, sediment, and plant cover was begun near Dubois, Wyoming, at an elevation of about 9, 500 feet.

Figure W-9. -- The stream gages on the sagebrush watersheds are of a unique construction--made entirely of redwood. The large photo shows one gage at time of opening, on April 25. The small photo shows the completed gage. The wall containing the V-notch is made of 3- by 6-inch shiplap which is glued and nailed. Pond walls are of 2- by 6-inch redwood spaced 1/2 inch apart. The chief advantage of this type of stream gage is the relative ease with which the materials can be transported to remote areas.

Figure W-10 (below)--Wind is again expected to play an important role in the timing of snowmelt runoff on the sagebrush watersheds. Pictured here on April 30, is a deep drift that has accumulated in the lee of a small ridge. Maximum water content of this drift was 44 inches, compared with 10 inches or less in the surrounding area. Snow from the deepest drifts lasted until early July -- in comparison with the nondrift areas, which were bare by late May.

Prediction equation developed for streamflow in the Black Hills

Station Paper No. 44 by Howard Orr in 1959 describes in detail the precipitation and streamflow of the Black Hills. Annual runoff on the Rapid Creek watershed increases an average of 0.204 area-inch for every 1-inch increase in annual precipitation. This holds true for the measured range of annual precipitation from 11.76 to 34.80 inches between 1915 and 1942. The relationship is linear and is defined by the following equation:

$$Y = 0.2042\,X_1 - 1.0831$$

where

Y = estimated runoff in inches

X_1 = annual precipitation in inches

The water yield in a calendar year also increases with increase in the amount of precipitation in the preceding September-December period. With this factor included, the relationship becomes:

$$Y = 0.2042\,X_1 + 0.5545\,X_2 - 3.3360$$

where

Y = estimated runoff in inches

X_1 = annual precipitation in inches

X_2 = antecedent September-December precipitation in inches

The two precipitation factors together account for 70 percent of the variation in annual runoff.

Thinned ponderosa pine uses 1 inch less water than unthinned pine

In the Black Hills, a study is underway to compare water use on unthinned, thinned, and clear-cut sites. Moisture content of the upper 4-1/2 feet of soil was less under unthinned than under thinned ponderosa pine both at the start and at the end of a 14-week period during the summer of 1958. The unthinned stand used 1.2 inch more total moisture during this period than the thinned stand. These results are summarized in the following tabulation:

Item	Clear cut	Thinned	Unthinned
	- - - -	(Inches)	- - - -
Moisture content:			
Start	18.5	17.9	14.9
End	17.8	12.8	8.6
Reduction	0.7	5.1	6.3
Gross precipitation	7.0	6.9	6.7
Seepage	--	0	0
Water use	--	12.0	13.0

The thinned plot had 435 trees per acre and they averaged 5.8 inches d.b.h. There were 2,885 trees per acre on the unthinned plot, averaging 3.3 inches d.b.h. Basal area was about 80 square feet per acre on the thinned plot as compared with 171 square feet per acre on the unthinned plot. Both stands were 65 to 70 years old.

The upper 4-1/2 feet of soil in the study area held 19.4 inches of water at storage capacity. Moisture content at wilting point was 9.8 inches of water. Thus, 9.6 inches of water are available for plant growth when the soil is at storage capacity, or 2.1 inches of water per foot of soil.

On the starting date there were 8.7 inches of available water on the clear-cut area, 8.1 inches on the thinned plots, and 5.1 inches on the unthinned plots. Fourteen weeks later there were still 8.0 inches of available water on the clear-cut plot, 3.0 inches under the thinned stand, but none under the unthinned stand.

Evaporation losses from the clear-cut plot were measured only from about the upper 18 inches of soil. This plot may have contributed some seepage to ground water. There was some moisture depletion throughout the profile on the thinned area, but no part of the profile was reduced to wilting point, except perhaps the surface few inches. The unthinned stand apparently drew all available moisture from the entire soil profile.

Bluegrass bottomlands produce runoff only during major storms

The ponderosa pine cover of the Black Hills is interrupted by numerous stringers of bottomlands covered with Kentucky bluegrass. To learn how much surface runoff these bluegrass ranges produce, runoff plots were installed (fig. W-11).

Figure W-11. -- Surface runoff plot on Kentucky bluegrass in the Black Hills. Two 4- by 10.9-foot (1 milacre) plots such as this were installed on April 28, 1959, as well as a 16- by 16-foot plot. Total precipitation to September 8, was 9.37 inches. Runoff totaled 0.25 and 0.26 inch from the milacre plots--averaging 2.7 percent of total precipitation. This compared favorably with 0.24 inch from the 16- by 16-foot plot.

Most of the runoff came from a single storm of 0.79 inch, of which 0.45 inch fell in 5 minutes. Runoff was 0.21 and 0.19 inch, respectively, from the milacre plots, and 0.21 inch from the 16- by 16-foot plot. The 1-milacre plots have yielded about the same amounts of runoff as the 16- by 16-foot plot, but the smaller plots are less expensive and easier to install and operate.

Between 7 and 25 percent of the total precipitation evaporates from the forest floor

A little understood phase of water use is the exchange of moisture between the forest floor and the atmosphere. Studies of this phenomenon are aimed eventually at learning how much water is lost by evaporation from different types of forest floor--keeping in mind that all such "losses" must be considered as relative because a certain amount of evaporation occurs from all natural surfaces regardless of whether they are bare soil, rock, or organic material.

Between 0.2 and 1.1 inches of moisture were evaporated from the forest floor on 9 plots of pole-sized ponderosa pine during 1 month of the summer rainy season (table W-3). This represented 7 to 25 percent of gross precipitation. Forest floor was considered to be the litter and humus layer that covers mineral soil. The total evaporation was directly and significantly related to the amount of gross precipitation falling on the plots during the study period and to the weight of the forest floor found on the plots.

Table W-3.--Forest-floor moisture data for the period August 1 to 30, 1957

Location	Forest floor weight	Rainfall	Evaporation	Evaporation as percent of rainfall
	Tons/acre	Inches	Inches	Percent
89A	3.7	2.5	0.2	8
Fort Valley	4.9	1.8	.2	11
Beaver Creek	5.8	4.2	.3	7
Fort Valley	10.4	3.9	.5	13
89A	10.9	3.7	.5	14
89A	13.2	3.9	.6	15
Fort Valley	17.4	2.4	.6	25
Beaver Creek	18.4	4.4	.8	18
Beaver Creek	21.1	6.4	1.1	17

Pinyon-juniper intercepts 8 to 21 percent of total precipitation

Figure W-12.--Interception of precipitation was measured in pinyon-juniper stands such as this on Beaver Creek near Camp Verde in central Arizona.

There is a certain amount of precipitation that doesn't reach the ground but is intercepted by tree canopies. In three densities of pinyon-juniper near Camp Verde, Arizona, this amount varied from 8 to 21 percent. It should be kept in mind that total evapo-transpiration is not necessarily increased by the amount of interception. All or most of the intercepted rainfall would have evaporated from the soil or been used by plants if not caught by the tree canopy. Average results over a 1-year period are shown in table W-4.

Table W-4. --Interception[1] in the pinyon-juniper type and its relationship to stand density

Stand density	Crown cover	Trees per acre taller than 6 feet	Precipitation	Interception	Interception as percent of precipitation
	Percent	Number	Inches	Inches	Percent
Light	17	45	15.0	1.2	8
Medium	42	160	15.0	2.7	18
Dense	59	220	15.0	3.2	21

[1] Stemflow was found to be negligible.

Runoff in the chaparral type before and after fire (central Arizona)

During the 1956-57 water year, all of the streamflow from the chaparral-covered watersheds on the 3-Bar allotment near Roosevelt, Arizona, came during the winter and spring months. A single 8.61-inch January storm produced 40 percent of the total runoff, and heavy runoff following this storm brought only a trace of sediment to the weir basins. Eighty-six percent of the total precipitation fell between October 1 and May 31, the period most favorable to water yield. Recovery of total precipitation ranged from 0 on watersheds A and B to 9 percent on watershed D (table W-5).

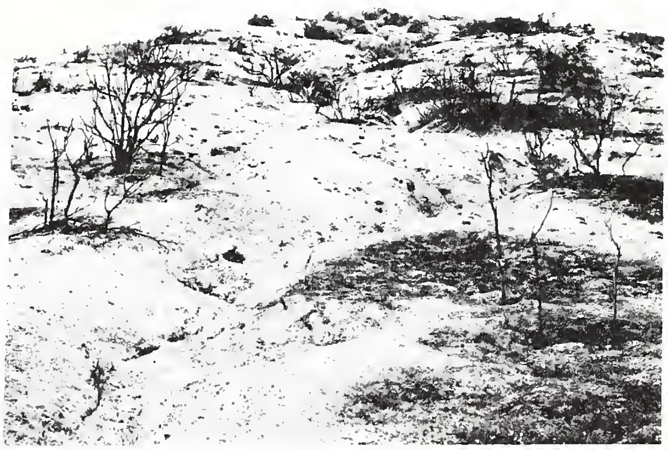


Figure W-13. --In June 1959, the 3-Bar watersheds were burned, leaving the land in the condition shown above. Although the fire was not a planned part of the research program, the effect on streamflow and sediment movement will be measured.

Table W-5. --Precipitation and runoff on 3-Bar watersheds, 1956-57 water year

Watershed	Total precipitation	Oct. 1-May 31 precipitation	Runoff	Runoff as percent of total precipitation
	Inches	Inches	Inches	Percent
A	23.0	19.6	Trace	0
B[1]	25.1	21.7	0	0
C	25.1	21.7	1.8	7
D	26.0	22.0	2.4	9

[1] Record taken from gage at adjacent watershed C.

Figure W-14. --Heavy rains that followed the fire at 3-Bar, showed a complete change in the character of streamflow, though it is too early for a full evaluation. However, in contrast with conditions in 1956-57, this year's summer storms have caused streamflow on all watersheds. This has been at the expense of large discharges of sediment, which fill the weir ponds and debris basins. Photo shows the stream gage on watershed C following a storm on August 4.

Factors influencing establishment of phreatophytes

A vegetation type of great interest in the field of plant-water relationships is phreatophytes. These plants grow with their roots in or near the water table and may be extravagant water users. A great deal of research is being done to find ways of controlling phreatophytes.

One control method employs the ecological approach in which the susceptibility of the plants to environmental changes is studied. Germination tests of seed of five-stamen tamarisk, seepwillow, broom baccharis, arrowweed, and Fremont cottonwood have been made during the past 2 years by spreading seed on moist filter paper in closed Petri dishes. Except for special tests of the effect of temperature, seed was stored in the laboratory where temperatures varied between 72°F. and 80°F.

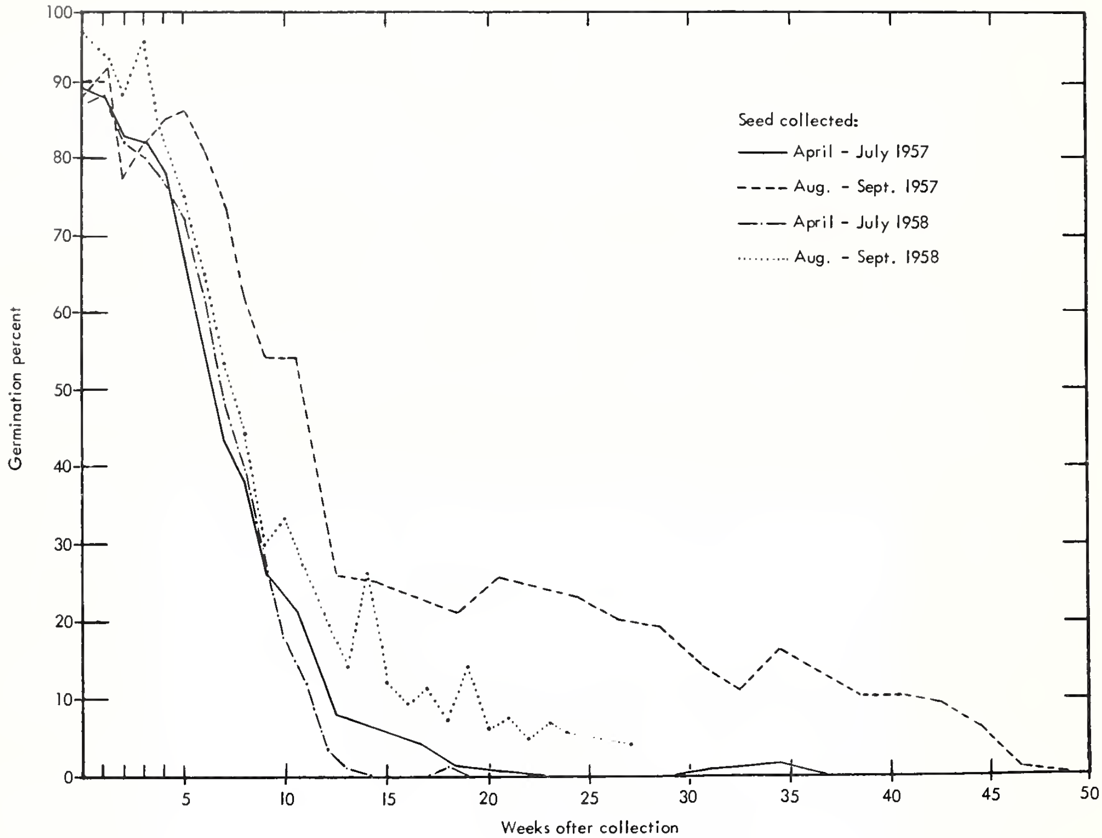


Figure W-15. --Loss in germination of tamarisk seed collected at different seasons. Seeds collected in the spring of 1957 and 1958 lost nearly all viability by the following winter, except for an occasional seed. Thus, seeds produced in the spring do not carry over to germinate the following spring.

Seeds ripening in the summer (August-September) of 1957 maintained some viability for nearly a year, though 75 percent of the seeds gave no germination after 12 weeks. Seeds collected during the summer of 1958 also retained some vitality 6 months after collection. Thus, summer seeds may carry over and germinate in the next growing season.

Seepwillow seed gave a lower initial germination than tamarisk seed, but germinating capacity was retained for a long period. Spring seeds have a higher germination rate than fall seeds. Broom baccharis seeds collected in November 1957 had a viability of 90 percent after 18 months of storage. Fremont cottonwood seed lost all viability by the seventh week after collection. Some lots of arrowweed seed gave high germination percentages, while others averaged only 10 percent or lower. A fairly constant germination seems to be retained for at least a full year by this species.

High temperatures shorten viability period of tamarisk and seepwillow

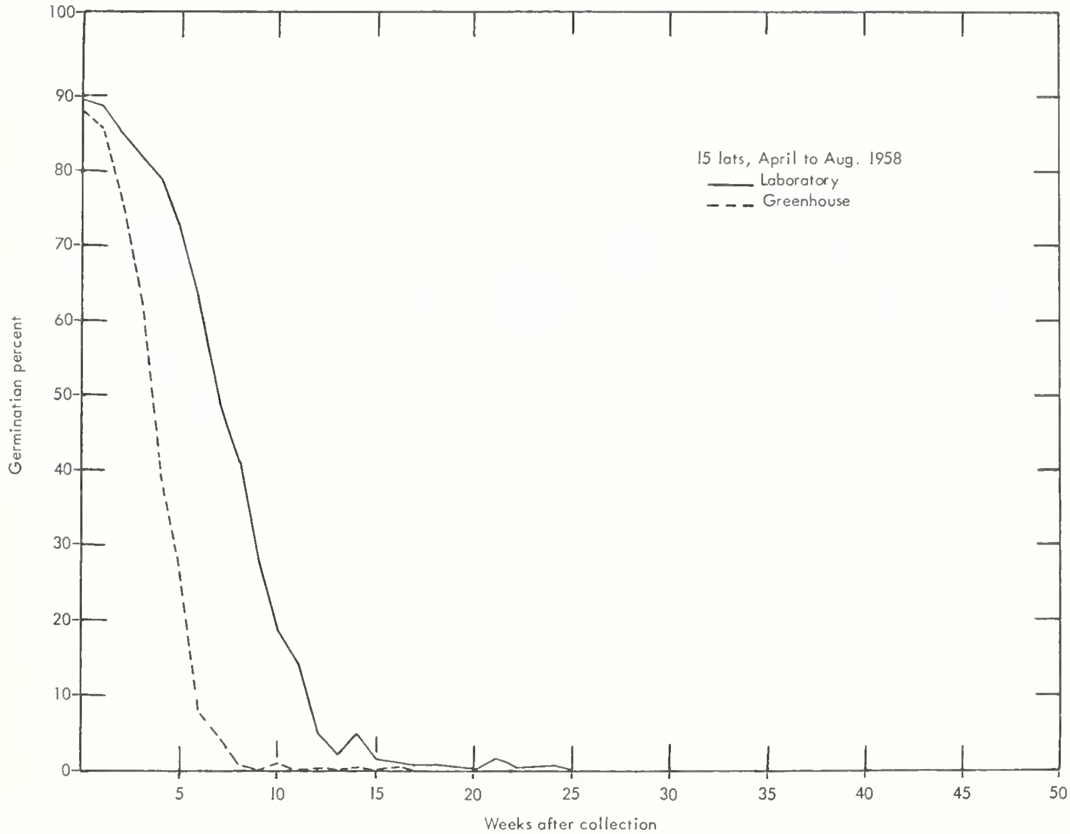


Figure W-16.--High temperatures, comparable to those in the field, were found to reduce viability of tamarisk seed. A portion of each of 15 lots collected in the spring and summer of 1958 were stored in a well-ventilated greenhouse where temperatures were 95°F. to 105°F., or approximately the same as those in the field. Greenhouse-stored seed deteriorated about twice as fast as seed stored in the laboratory at 72°F. to 80°F.

Flood flows remove established seedlings
but also deposit new seed

Figure W-17. --Establishment of phreatophytes along the Salt River is sometimes helped and sometimes hindered by flood flows.

Because tamarisk and seepwillow seeds germinate in wet soils or on water surfaces, excellent conditions for seedling establishment are provided by receding flood flows. At the beginning of February 1957, the entire channel area from near high-water mark down to low water was covered with abundant tamarisk and a few seepwillow seedlings that had become established in the fall of 1956. During the first part of March the flow in the Salt River increased and removed all the submerged seedlings. As the water receded, only seepwillow seedlings became established because tamarisk seeds had not yet ripened.

High water in early April again removed many seedlings, leaving an upper bank of mixed fall-established seedlings and a lower bank of seepwillow. During the receding April flow, 20 to 100 tamarisk seedlings per square foot became established. A slight rise in river flow in early May removed some seedlings, but a new crop developed as this flow receded.

In the first weeks of June a major flow removed all seedlings, and except for a recession in the middle of June, high flow kept all seedlings from developing in the study area.

Apparently, seedlings become permanently established only after high flows that not only recede during periods of abundant seed, but also are not followed by subsequent flows of equal height.

PUBLICATIONS

Range Managemer and Wildlife Habitat Research

BOHNING, J. W.
Salting for better livestock distribution. In Your range--its management. Ariz. Agr. Expt. Sta. and Ariz. Ext. Serv. Spec. Rpt. 2, pp. 30-31.

On semidesert g ass-shrub range where salt and water are some distance apart, cattle may graze several hours between licking salt and drinking. Salt or meal-salt mixture placed on lightly grazed areas helps to obtain more uniform utilization.

CABLE, D. R.
Some effects of fire and drouth on semidesert grasses and shrubs. Ariz. Univ. Watershed Mangt. Dept. Master Sci. Thesis. 27 pp.

Reports burning study on Santa Rita Experimental Range.

_______ and BOHNING, J. W.
Changes in grazing use and herbage moisture content of three exotic lovegrasses and some native grasses. Jour. Range Mangt. 12: 200-203, illus.

Cattle preferred Arizona cottontop earlier in the season, September through June, than any of the lovegrasses. Utilization of Lehmann lovegrass lagged behind all other species until late in the spring. Otherwise the general patterns of use of the native and introduced grasses were similar. The results suggest that management of a semidesert grass-shrub range with a mixture of native grasses and lovegrasses should be no more difficult than managing for native perennials alone.

COTNER, M. L., and JAMESON, D. A.
Costs of juniper control: Bulldozing vs. individual tree burning. Station Paper 43, 14 pp., illus. [Processed.]

Burning is cheaper than bulldozing for small-tree stands of juniper and for sparse stands of large trees. In dense stands of large trees neither of the methods showed a cost advantage.

HURD, R. M.
Factors influencing herbage weight of Idaho fescue plants. Jour. Range Mangt. 12: 61-63.

The relationship of maximum leaf height, basal area, and number of flower stalks to herbage weight of the individual plant are analyzed.

JAMESON, D. A.
Use of fire in control of juniper in Arizona (Abstract). West. Weed Control Conf. Ann. Res. Progress Rpt. 1959: 20. [Processed.]

Summarizes results from three studies involving the intentional use of fire in the pinyon-juniper type as a range-improvement practice: (1) burning slash following mechanical control operations, (2) burning grass stands to kill small individual trees, and (3) comparative costs of dozing and individual tree burning in control operations.

_______ and HUSS, D. L.
The effect of clipping leaves and stems on number of tillers, herbage weights, root weights, and food reserves of little bluestem. Jour. Range Mangt. 12: 122-126, illus.

Tillering of little bluestem plants following clipping was greatest just before plant maturity when apical meristems were elevated enough to be removed by clipping. Plants with both leaves and stems clipped produced more herbage for the season, but smaller root weights, than plants with only leaves or only stems clipped. Clipping both leaves and stems did not reduce carbohydrate reserves more than clipping leaves alone.

JOHNSON, W. M.
Grazing intensity trials on seeded ranges in the ponderosa pine zone of Colorado. Jour. Range Mangt. 12: 1-7, illus.

Grazing of crested wheatgrass to a 2-inch stubble height had little effect on herbage yield but production of intermediate wheatgrass and smooth brome declined when grazed to this level. Grazing Russian wildrye to a 1-1/2-inch stubble height did not lower herbage yield.

KEITH, J. O., HANSEN, R. M., and WARD, A. L.
Effect of 2,4-D on abundance and foods of pocket gophers. Jour. Wildlife Mangt. 23: 137-145, illus.

A report on changes in vegetation, gopher abundance, and gopher food habits on Thurber fescue mountain grasslands after the range was sprayed with the herbicide 2,4-D.

KLIPPLE, G. E., and RETZER, J. L.
Response of native vegetation of the central Great Plains to applications of corral manure and commercial fertilizer. Jour. Range Mangt. 12: 239-243, illus.

Application of 10 tons per acre of cow manure increased herbage yields 15 to 50 percent. Yields on plots treated with commercial fertilizer seldom exceeded untreated native range.

McEWEN, L. C., and HURD, R. M.
Deer exclosures. S. Dak. Conserv. Digest 26(2): 38-40, illus.

Deer exclosures are used in the study of germination, survival, and growth of artificially planted browse species in the Black Hills. Preliminary results of browse planting trials are given.

MARTIN, S. C.
To control mesquite economically start early and keep at it. In Your range--its management. Ariz. Agr. Expt. Sta. and Ariz. Ext. Serv. Spec. Rpt. 2, pp. 15-16, illus.

Although scattered stands of mesquite are not striking, they are most economical to control. Early control prevents declines in forage production which takes place when mesquite forms dense stands of mature trees.

MAY, MORTON
Winter elk range in the Sunlight Basin, Wyoming. Colo.-Wyo. Acad. Sci. Jour. 4 (11): 36.

Preliminary report comparing utilization by elk and cattle when both species graze the same range. Vegetation changes on an ungrazed area, an area grazed only by elk, and by both cattle and elk are discussed briefly.

PINGREY, H. B., and DORTIGNAC, E. J.
Economic evaluation of seeding crested wheatgrass on northern New Mexico rangeland. N. Mex. Agr. Expt. Sta. Bul. 433, 80 pp., illus.

Basic field data on beef production, herbage yield, herbage utilization, and stocking rates is presented for three experimental locations in north-central New Mexico. Economic information on grazing large seeded tracts is also presented.

REYNOLDS, H. G.
Brush control in the Southwest. In Grasslands. Amer. Assoc. Adv. Sci. Pub. 53, pp. 379-389, illus.

Discusses causes of invasion, methods for control, and benefits of control for the principal woody plants of the Southwest.

———
Managing grass-shrub cattle ranges in the Southwest. U. S. Dept. Agr. Agr. Handbook 162, 40 pp., illus.

A comprehensive review of management of grass-shrub cattle ranges of the Southwest, based on results of numerous studies conducted on the Santa Rita Experimental Range. Characteristics of the climate and vegetation, range conditions, stocking rates, forage utilization, proper handling of livestock, and range-improvement practices are discussed. These are summarized in nine recommendations for managing grass-shrub ranges.

———
Range reseeding practices in Arizona. In Your range--its management. Ariz. Agr. Expt. Sta. and Ariz. Ext. Serv. Spec. Rpt. 2, pp. 26-27, illus.

Reseeding recommendations for ponderosa pine, big sagebrush, pinyon-juniper, and desert grassland ranges are briefly discussed.

———
Vegetation types of Arizona in relation to grazing use. In Your range--its management. Ariz. Agr. Expt. Sta. and Ariz. Ext. Serv. Spec. Rpt. 2, pp. 8-9, illus.

Dominant vegetation, growing conditions, grazing use, and grazing capacity are described for forests, woodlands, chaparral, grasslands, and desert shrub types of Arizona.

SCHMUTZ, E. M., CABLE, D. R., and WARWICK, J. J.
Effects of shrub removal on the vegetation of a semidesert grass-shrub range. Jour. Range Mangt. 12: 34-37, illus.

Chaining a semidesert grass-shrub area, knocked down large cholla plants, and opened up the shrub stand. Large numbers of cholla joints sprouted following treatment and the effect appears to be only temporary. The chaining had no measurable effect on perennial grasses.

SMITH, D. R.
How you graze makes the difference. Amer. Hereford Jour. 49(17): 112-113, 116, illus.

Reports 18 years of research on a bunchgrass range in ponderosa pine country of the Rocky Mountains. Recommends 30 to 40 percent removal of desirable grasses and sedge, as the optimum grazing intensity for maintaining forage and cattle production.

SPRINGFIELD, H. W.
Estimating the utilization of crested wheatgrass from counts of grazed plants. Research Note 38, 6 pp., illus. [Processed.]

Describes a rapid, reliable, easy-to-use method for judging spring utilization of crested wheatgrass by sheep and cattle.

U. S. FOREST SERVICE
Research on Black Mesa--a progress report. Station Paper 41, 18 pp., illus. NA [Processed.]

Discusses research results in grazing management, watershed management, and range rodents on high-elevation Thurber fescue grassland parks interspersed in groves of spruce and aspen in southwestern Colorado.

Forest Biology

GOODRUM, P. D., and REID, V. H.
Deer browsing in the longleaf pine belt. Soc. Amer. Foresters Proc. 1958: 139-143.

Based on browsing studies of deer in enclosures, high- and medium-choice woody food plants are listed. Fawn production drops sharply when choice plants show overbrowsing. Suggests method of judging condition of deer range.

Forest Management Research

BAGLEY, W. T., and READ, R. A.
Trees--treat them as you would a cash crop. Nebr. Expt. Sta. Quart. 6(2): 10-11, illus.

General information on tree research program at University of Nebraska and the Lincoln Research Center.

GAINES, E. M., and SHAW, E. W.
Half a century of research--Fort Valley Experimental Forest, 1908-1958. Jour. Forestry 57: 629-633, illus.

Briefly reviews the history and accomplishments of forest management research at Fort Valley, and mentions the problems ahead.

LARSON, M. M.
Regenerating aspen by suckering in the Southwest. Research Note 39, 2 pp., illus. [Processed.]

For best results young aspen suckers should be protected from browsing by livestock.

____
Some observations on initial root development in ponderosa pine seedlings. Forestry Sect. Northwest. Sci. Assoc. Proc. 32: 4-5. [Processed.]

Reports factors that appeared to affect first-year root growth of ponderosa pine seedlings. Root length was related to date of germination. Cessation of growth was related to temperature.

LINDENMUTH, A. W. Jr., and GILL, L. S.
Nature's slash "dispose-all." Timberman 60 (9): 42-43, illus.

By holding moisture in decaying slash, the fungus Polyporus anceps Pk. reduces the flammability and therefore the fire hazard of ponderosa pine slash.

WOODRUFF, N. P., READ, R. A., and CHEPIL, W. S.
Influence of a field windbreak on summer wind movement and air temperature. Kans. Agr. Expt. Sta. Tech. Bul. 100, 24 pp., illus.

Reports the influence of a field windbreak on wind velocity, day and night air temperatures, relative humidity, and transpiration of field crops.

Forest Insect Research

HELLER, R. C., BEAN, J. L., and KNIGHT, F. B.
Aerial surveys of Black Hills beetle infestations. Station Paper 46, 8 pp., illus. [Processed.]

Results of tests for estimating number of red tops by sketch mapping, counts by operations recorder, and aerial photographs. Most accurate estimates were obtained from color photographs, scale 1: 7, 920.

KNIGHT, F. B.
Measuring trend in Black Hills beetle populations. Colo.-Wyo. Acad. Sci. Jour. 4 (11): 56-57.

Abstract of paper presented at the annual meeting. Describes a procedure for sampling Black Hills beetle populations.

____
Measuring trend in populations of the Black Hills beetle. Research Note 37, 6 pp., illus. [Processed.]

Brood density beneath the bark on the lower bole gives a reliable estimate of insect numbers and infestation trend.

____
Partial life tables for the Black Hills beetle, Dendroctonus ponderosae Hopk. Jour. Econ. Ent. 52: 1199-1202, illus.

Life tables show that the critical mortality period for the Black Hills beetle is between April and July of the spring following the initial attack on the trees. These tables reveal very high mortalities among the developing beetles for all classes of infestations.

LANDGRAF, A. E.
Forest insect conditions in the central Rocky Mountains--1958. Station Paper 40, 19 pp. [Processed.]

Status and trends of insect infestations in Colorado, Wyoming, and South Dakota.

WYGANT, N. D.
Bark beetle control. Jour. Forestry 57: 274-277, illus.

A review and appraisal of bark beetle problems, control methods, and research needs.

———— Status of insect control on private forest lands in the Southwest. In Time for action in the woods. Timberland Owners Conf. Proc., Southwest. Region, Santa Fe, N. Mex., Sept. 1958, pp. 21-24, illus.

A summary of forest insect problems, the amount of insect-caused damage, and how timber losses can be reduced by cooperative efforts.

Forest Disease Research

DAVIDSON, R. W., HINDS, T. E., and HAWKSWORTH, F. G.
Decay of aspen in Colorado. Station Paper 45, 14 pp., illus. [Processed.]

Discusses the relative abundance of various wood-destroying fungi and the relation of heart rot losses to aspen management.

ESLYN, W. E.
Hemerocampa pseudotsugata McDun.--a new host for *Beauveria bassiana* (Bals.) Vuill. Jour. Insect Path. 1: 434-435.

Records the occurrence of a fungus parasite of Douglas-fir tussock moth larvae.

———— Radiographical determination of decay in living trees by means of the thulium X-ray unit. Forest Science 5: 37-47, illus.

Describes the testing of the thulium X-ray unit for detection of decay in living silver maple trees. Discusses future possibilities, problems, and methods of use in relationship to other tree species.

GILL, L. S.
Status of disease control on private forest lands in the Southwest. In Time for action in the woods. Timberland Owners Conf. Proc., Southwest. Region, Santa Fe, N. Mex., Sept. 1958, pp. 25-28, illus.

Discusses forest disease problems of the small landowner with suggestions for control, including financing.

HAWKSWORTH, F. G.
Ballistics of dwarfmistletoe seed. Science 130 (3374): 504, illus.

Gives experimental data and formulas for computing trajectories and velocities of dwarfmistletoe seeds. Velocities found to approximate 45 feet per second and initial acceleration approached 5, 000 times gravity.

———— Distribution of dwarfmistletoes in relation to topography on the Mescalero Apache Reservation, New Mexico. Jour. Forestry 57: 919-922, illus.

Discusses the frequency of ponderosa pine and Douglas-fir dwarfmistletoes in relation to topographic position, steepness of slopes, aspect, and elevation.

———— Dwarfmistletoes of ponderosa pine. IX Internatl. Bot. Cong. Proc. 2: 154.

[Abstract.] Discusses primarily the physiology and ecology of *Arceuthobium vaginatum* f. *cryptopodum*.

______ and HINDS, T. E.
Progress report on the rate of deterioration of beetle-killed Engelmann spruce in Colorado. Research Note 36, 6 pp., illus. [Processed.]

States that spruce stands killed by bark beetles suffer more than 30 percent cubic-foot volume loss through windfall and decay in 15 years following insect attack.

______ and PETERSON, R. S.
Notes on the hosts of three pine dwarfmistletoes in northern Colorado. U. S. Agr. Res. Serv. Plant Dis. Rptr. 43: 109-110, illus. [Processed.]

Reports the occurrence of *Arceuthobium americanum*, *A. vaginatum* f. *cryptopodum*, and *A. campylopodum* f. *cyanocarpum* on each of the following pines: lodgepole, ponderosa, and limber.

LEAPHART, C. D., and GILL, L. S.
Effects of inoculations with *Leptographium* spp. on western white pine. Phytopathology 49: 350-353, illus.

Demonstrates that *Leptographium* spp. associated with pole blight of western white pine exhibits wide variation in pathogenicity.

PETERSON, R. S.
The *Cronartium coleosporioides* complex in the Black Hills. U. S. Agr. Res. Serv. Plant Dis. Rptr. 43: 1227-1228. [Processed.]

General observations on western gall rusts and other pine rusts in the Black Hills.

______
Pine gall rust in the Rocky Mountains. Diss. Abs. 20: 1557.

Abstract of doctoral thesis on western gall rust (*Peridermium harknessii*) of western hard pines. Deals with its life cycle, factors influencing susceptibility, and kinds of injury to pines.

Forest Utilization Research

HERMAN, F. R.
Logging in high-altitude forests of the central Rocky Mountains. Soc. Amer. Foresters Proc. 1958: 19-21.

New logging techniques may be required if we are to efficiently extend forest and watershed management to places where management is not possible now. Wyssen and gravity slack-line cable operations in Colorado are discussed.

KOTOK, E. S., and NEWPORT, C. A.
Lumber recovery at a ponderosa pine sawmill in the Black Hills. Station Paper 19 (revised), 14 pp., illus. [Processed.]

Study includes lumber-recovery data reported in earlier edition, plus the results of tests to apply the log grades to tree grades.

LANDT, E. F., and WOODFIN, R. O., Jr.
Amount and grades of lumber from Black Hills ponderosa pine logs. Station Paper 42, 24 pp., illus. [Processed.]

Lumber quantity and quality were determined at four different types of sawmills operating in the Black Hills. Overrun and lumber-grade recovery are reported for logs graded by Pacific Northwest log grades.

_______ and WOODFIN, R. O., Jr.
Pulpwood characteristics of Black Hills ponderosa pine. Tech. Assoc. Pulp and Paper Indus. 42: 809-812, illus.

Solid wood content of rough and peeled cords and other pulpwood characteristics were determined on stacked 100-inch long bolts of ponderosa pine.

MUELLER, L. A.
Beetle-killed Engelmann spruce shows promise as a raw material for particle board. Research Note 35, 6 pp., illus. [Processed.]

Suitability of beetle-killed Engelmann spruce was determined for the production of particle board.

____
What can be done to improve utilization of the timber resources in the Southwest. In Time for action in the woods. Timberland Owners Conf. Proc., Southwest. Region, Santa Fe, N. Mex., Sept. 1958, pp. 29-35, illus.

Paper outlines the industrial opportunities that offer promise for improved utilization of the timber resource.

Forest Economics Research

MILLER, R. L.
Lumber production in Colorado--1957. Forest Survey Release 1, 9 pp., illus. [Processed.]

Presents Colorado's 1957 lumber output of 188 million board feet mill production class, species, and county, describes the sawmill industry, and shows an upward trend in production.

_______ and WILSON, A. K.
Lumber production in Wyoming--1957. Forest Survey Release 2, 9 pp., illus. [Processed.]

Presents Wyoming's 1957 lumber output of 109 million board feet by mill production class, species, and county, describes the sawmill industry, and shows an upward trend in production.

Watershed Management Research

DECKER, J. P., and TIO, M. A.
Photosynthetic surges in *Coffea arabica*. Puerto Rico Univ. Jour. Agr. 43: 50-56.

Reports a study of respiration and photosynthesis of coffee plants under different light conditions; discusses possible interrelationships with dry weight increment.

GOODELL, B. C.
Management of forest stands in western United States to influence the flow of snow-fed streams. Symposium of Hannoversch-Münden, Internatl. Sci. Hydrol. Assoc., Pub. 48, 1: 49-58.

Discusses solar radiation and canopy interception in coniferous forests and the effect of these factors on snowmelt and evaporation; also considers application to forest management.

——— Watershed studies at Fraser, Colorado. Soc. Amer. Foresters Proc. 1958: 42-45, illus.

Summarizes the effects on streamflow of strip-cutting the Fool Creek watershed.

HOOVER, M. D.
Vegetation and land-use effects. (Abstract.) Amer. Geophys. Union Trans. 39: 519. [Not listed in the Station's 1958 Annual Report.]

Discusses the role of forest and range vegetation in determining streamflow and soil stability.

HORTON, J. S.
The problem of phreatophytes. Symposium of Hannoversch-Münden, Internatl. Sci. Hydrol. Assoc. Pub. 48, 1: 76-83.

Describes Forest Service studies of phreatophytes (chiefly tamarisk). Studies are concerned with life history, water use, and control methods.

KOSHI, P. T.
Soil-moisture trends under varying densities of oak overstory. U. S. Forest Serv., South. Forest Expt. Sta. Occas. Paper 167, 12 pp., illus. [Processed.]

Describes a study of soil moisture depletion under oak in Texas; special consideration is given to availability of moisture to plants, seasonal depletion, and depletion from various soil depths.

LOVE, L. D.
Rangeland watershed management. Soc. Amer. Foresters Proc. 1958: 198-200, illus.

On the basis of selected range-watershed studies in grasslands illustrates the major factors of desirable watershed management. The factors are: (1) a cover of herbaceous vegetation consisting of a high percentage of desirable bunchgrasses, (2) a large amount of litter covering the soil surface, (3) a small percentage of bare or exposed soil, and (4) high noncapillary porosity of surface soils consistent with soil profile characteristics.

MARTINELLI, M., Jr.
Alpine snowfields--their characteristics and management possibilities. Symposium of Hannoversch-Münden, Internatl. Sci. Hydrol. Assoc. Pub. 48, 1: 120-127, illus.

Adds two more years' record to the material reported in the Journal of Geophysical Research.

——— Some hydrologic aspects of alpine snowfields under summer conditions. Jour. Geophys. Res. 64: 451-455, illus.

Reports ablation, density, weather factors, water equivalent of ablation, and net moisture exchange between atmosphere and snow surfaces for selected snowfields in Colorado. Proposals are made to sustain summer streamflow by constructing barriers to drift additional snow in natural accumulation areas.

REYNOLDS, H. G., and GLENDENING, G. E.
Research in management of chaparral lands. Ariz. Cattlelog 14(12): 13-16, illus.

Summarizes history of chaparral research and describes current studies dealing with chaparral eradication, revegetation, and deer use.

RICH, L. R.
Hydrologic research using lysimeters of undisturbed soil blocks. Symposium of Hannoversch-Münden, Internatl. Sci. Hydrol. Assoc. Pub. 49, 2: 139-145, illus.

Discusses construction methods and findings of the Base Rock lysimeters at the Sierra Ancha Experimental Forest, Arizona.

SHAW, E. W.
The alpine yields its secret -- water. West. Farm Life 60(6): 5, illus.

Popular summary of the station's snow research in the Colorado alpine.

General

PRICE, RAYMOND.
Summary of conference highlights. In Time for action in the woods. Timberland Owners Conf. Proc. Southwest. Region, Santa Fe, N. Mex., Sept. 1958. pp. 40-44.

SHAW, E. W.
Federal research in forestry at CSU. The Cruiser (Colo. State Univ. Forestry College) 21(3): 7. [Processed.]

Shows the work of the Rocky Mountain Station and its relation to the College of Forestry and Range Management at Colorado State University.

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